



## The 12<sup>th</sup> Japan-U.S. Seminar on Two-Phase Flow Dynamics 2022 (JP-US STPFD'22)

May 8-11, 2022, Virtual Meeting

University of Michigan  
Ann Arbor, Michigan, USA

**Organized by:** College of Engineering, University of Michigan

**Co-organized by:** The Japanese Society for Multiphase Flow

**Sponsored by:** LaVision, Inc.

Department of Nuclear Engineering and Radiological Sciences,  
College of Engineering, University of Michigan

**Honorary Chair** Mamoru Ishii Purdue University, USA

**General Chair:** Steven Ceccio University of Michigan, USA

**General Co-Chair:** Yuichi Murai Hokkaido University, Japan

**Program Chair:** Xiaodong Sun University of Michigan, USA

**Program Co-chair:** Shuichiro Miwa University of Tokyo, Japan



日本混相流学会  
The Japanese Society for Multiphase Flow



COLLEGE OF ENGINEERING  
**NUCLEAR ENGINEERING & RADIOLOGICAL SCIENCES**  
UNIVERSITY OF MICHIGAN

# Welcome to JP-US STPFD'22

It is our great pleasure to welcome all participants to the 12<sup>th</sup> Japan-U.S. Seminar on Two-Phase Flow Dynamics 2022 (JP-US STPFD'22) via the Zoom virtual meeting platform hosted by the College of Engineering, the University of Michigan from May 9 to 11, 2022. Since the first meeting held in 1979 in Kansai, Japan, the JP-US STPFD has provided an excellent platform for the scientists and researchers working on multiphase flows from both countries to exchange the latest research findings and receive feedback, and promote academic and research collaboration.

This 12<sup>th</sup> edition of NURETH was scheduled to take place in May 2020, but due to the ongoing COVID-19 pandemic, it was postponed three times, finally to May 2022, with the hope to have an in-person meeting. In February 2022, it was decided to move JP-US STPFD'22 to a virtual setting. We regret not being able to welcome you in person in Ann Arbor, Michigan, but hope this virtual meeting will still be productive and enjoyable.

JP-US STPFD'22 contains one plenary lecture, three keynote lectures, and 38 technical paper presentations (in 10 sessions), as well as a virtual laboratory tour and a special session on "Nationwide Research Programs on Multiphase Flows" for both countries. Due to the time differences between the two countries (and the time zones in the US), the meeting will be held in (early) mornings and evenings/nights over the three days. We are sorry for any inconvenience but appreciate you accommodating this meeting schedule.

JP-US STPFD'22 is co-organized by the College of Engineering, University of Michigan, and the Japanese Society for Multiphase Flow and sponsored by LaVision, Inc., and the Department of Nuclear Engineering and Radiological Sciences, University of Michigan. The seminar organizers greatly appreciate their support. Furthermore, the organizers would like to extend our appreciation to the authors, participants, and session chairs/co-chairs. A very special "thank you" goes out to those who contributed their time and effort to support this seminar, especially, Ms. Martha Sweigert, Ms. Colleen Root, Ms. Rebecca Duguay, Muyue Li, Shuai Che, Dr. Kyung Mo Kim and Dr. Chengqi Wang.

Finally, we hope you will find the meeting productive and enjoy reading the proceedings.

|                |                  |
|----------------|------------------|
| Mamoru Ishii   | Honorary Chair   |
| Steven Ceccio  | General Chair    |
| Yuichi Murai   | General Co-Chair |
| Xiaodong Sun   | Program Chair    |
| Shuichiro Miwa | Program Co-chair |

# Seminar Program

**Monday, May 9, 2022, 08:30 (US EDT); 21:30 (Japan)**

**08:30 – 09:50  
(US EDT)**

**Opening Plenary (Chairs: Steven Ceccio and Yuichi Murai)**

08:30 – 08:40

Welcoming remarks by Prof. Steven Ceccio, Associate Dean for Academic Affairs, College of Engineering, University of Michigan

08:40 – 08:50

Greetings by Prof. Hitoshi Soyama, President, The Japanese Society for Multiphase Flow

08:50 – 09:00

Seminar Overview, Yuichi Murai, General Co-Chair

09:00 – 09:50

**Plenary lecture** by Prof. Mamoru Ishii, Honorary Chair (Purdue University)

Advanced instrumentation and modeling framework for two-phase flow  
Mamoru Ishii, Guanyi Wang, Zhuoran Dang, Yang Zhao (*Purdue University*)

**09:50 – 10:00**

Break

**Monday, May 9, 2022, 10:00 (US EDT); 23:00 (Japan)**

**Session M1: Multiphase Flow Modeling and Simulation - I**, Session Chair: Shuichiro Miwa, (University of Tokyo)

10:00 – 10:20

Two scale Two-Fluid Model stability and simulations  
Martin Lopez-de-Bertodano (*Purdue University*), Alexander Lopez-de-Bertodano (*University of Chicago*), Krishna Chetty (*Advanced Cooling Technologies, Inc.*), John Buchanan (*Naval Nuclear Laboratory*), Alejandro Clauss (*CNEA-CONICET and Universidad Nacional del Centro*)

10:20 – 10:40

Simulation of highly viscous melt spreading using a particle method under no-slip and slip boundary conditions  
Ryo Yokoyama (*University of Tokyo*), Masahiro Kondo (*AIST Central 2*), Shunichi Suzuki, Shuichiro Miwa, Marco Pellegrini (*University of Tokyo*), Michael Johnson (*CEA, DES, IRESNE, DTN, SMTA, LEAG, and Scalian*), Arthur Denoix, Viviane Bouyer, Christophe Journeau (*CEA, DES, IRESNE, DTN, SMTA, LEAG*), and Koji Okamoto (*University of Tokyo*)

10:40 – 11:00

Trends in vapor generation and intergroup mass transfer in the two-group Two-Fluid Model in flows with phase change  
Joseph L. Bottini, Zhiee Jhia Ooi, Caleb S. Brooks (*University of Illinois*)

**Monday, May 9, 2022, 19:00 (US EDT); Tuesday, May 10, 2022, 08:00 (Japan)**

**Session M2: Bubble Motion, Drag, and Flow Mixing, Session Chair: Yang Liu (Virginia Tech)**

- 19:00 – 19:20 Slug-jamming of gas-liquid two-phase flow in a helically coiled tube  
Yuichi Murai (*Hokkaido University*) and Masaaki Ishikawa (*University of the Ryukyo*)
- 19:20 – 19:40 Behavior of single bubble chain in gallium eutectic alloy under influence of transverse magnetic field  
Hideki Murakawa, Xin Fu, Kazushi Adachi (*Kobe University*)
- 19:40 – 20:00 Cross-flow transport of bubbles by a hydrophobic strip in a horizontal turbulent channel flow  
Atsuhide Kitagawa (*Kyoto Institute of Technology*) and Yuichi Murai (*Hokkaido University*)
- 20:00 – 20:20 RCIC turbine sparger design for experimental studies of suppression pool thermal hydraulic behavior  
Kenneth Fossum, Dallin Keesling, and Karen Vierow Kirkland (*Texas A&M University*)
- 20:20 – 20:30 Break**

**Monday, May 9, 2022, 20:30 (US EDT); Tuesday, May 10, 2022, 09:30 (Japan)**

**Session M3: Two-phase Experiments, Session Chair: Caleb S. Brooks (University of Illinois)**

- 20:30 – 20:50 Radioactive aerosol control and decontamination in the decommissioning for nuclear power plant  
Avadhesh Kumar Sharma (*University of Tokyo*), Hui Liang (*Harbin Engineering University*), Shuichiro Miwa (*University of Tokyo*), Nejedt Erkan (*United Kingdom Atomic Energy Authority*), Shunichi Suzuki, Ryohei Terabayashi and Marco Pellegrini (*University of Tokyo*)
- 20:50 – 21:10 Effects of swirl intensity on interfacial and wall friction factors of annular flows in a vertical pipe  
Ryo Kurimoto, Ryoya Koto, Kosuke Hayashi and Akio Tomiyama (*Kobe University*)
- 21:10 – 21:30 Experimental investigation of flow instabilities in subcooled flow boiling  
Qingqing Liu (*University of Michigan and Dynaflow, Inc.*), Adam Burak (*University of Michigan*), Joseph Kelly (*U.S. Nuclear Regulatory Commission*), and Xiaodong Sun (*University of Michigan*)
- 21:30 – 21:50 Sliding bubbles inside turbulent boundary layers in a tilted channel  
Dong Ik Yoon, Hyun Jin Park, Yuji Tasaka, and Yuichi Murai (*Hokkaido University*)
- 21:50 – 22:10 Onset of axisymmetric sloshing in a food processor  
Tomoaki Watamura (*Kyoto Institute of Technology*) and Kazuyasu Sugiyama (*Osaka University*)
- 22:10 – 22:20 Break**

**Monday, May 9, 2022, 22:20 (US EDT); Tuesday, May 10, 2022, 11:20 (Japan)**

**Special Session: Virtual Laboratory Tours**

Session Chairs Yuichi Murai (Hokkaido University) and Xiaodong Sun (University of Michigan)

22:20 – 22:50 **Japan:** Hokkaido University, Shizuoka University, Muroran Institute of Technology, Kobe University, and Kumamoto University

**US:** Purdue University, North Carolina State University, Rensselaer Polytechnic Institute, University of Michigan

**Tuesday, May 10, 2022, 08:00 (US EDT); 21:00 (Japan)**

08:00 – 08:50      **Keynote lecture #1** by Prof. Yuka Iga (Tohoku University)  
Session Chair: Martin Lopez-de-Bertodano (Purdue University)  
Promotion of dissolved gas separation in cavitating flow by dynamic stimulation of unsteady cavitation  
Yuka Iga (*Tohoku University*)

08:50 – 09:00      **Break**

**Tuesday, May 10, 2022, 09:00 (US EDT); 22:00 (Japan)**

**Session T1:** Cavitation and Its Application, Session Chair: Yuka Iga (Tohoku University)

09:00 – 09:20      Cavitation peening by using the jet and the pulsed laser to introduce compressive residual stress into stainless steel  
Hitoshi Soyama (*Tohoku University*)

09:20 – 09:40      A nucleation methodology and a compressible multiscale model for cavitation  
Aditya Madabhushi, Karim Alamé, and Krishnan Mahesh (*University of Minnesota-Twin Cities*)

09:40 – 09:50      **Break**

**Tuesday, May 10, 2022, 09:50 (US EDT); 22:50 (Japan)**

**Session T2:** Multiphase Flow Modeling and Simulation - II, Session Chair: Eric Johnsen (University of Michigan)

09:50 – 10:10      Numerical investigation on the effect of drag reduction of large-sized bubble in horizontal channel flow  
Sang-Won Kim (*RIKEN Center for Computational Science*), Nobuyuki Oshima, Yuichi Murai, and Hyun Jin Park (*Hokkaido University*)

10:10 – 10:30      Computational studies of gas-liquid-solid flows  
Lei Zeng, Jiakai Lu, and Gretar Tryggvason (*Johns Hopkins University*)

10:30 – 10:50      Compressibility effects in bubble dynamics simulations  
Eric Johnsen, Shahaboddin Alahyari Beig, Minki Kim (*University of Michigan*)

10:50 – 11:10      RANS-based CFD simulation of jet induced mixing and jet impingement on large bubble in microgravity  
Eymon Lan (*Rensselaer Polytechnic Institute*), Michael Harris (*National Aeronautics and Space Administration Kennedy Space Center*), Wei Ji (*Rensselaer Polytechnic Institute*), Mamoru Ishii (*Purdue University*), and Shanbin Shi (*Rensselaer Polytechnic Institute*)

**Tuesday, May 10, 2022, 19:00 (US EDT); Wednesday, May 11, 2022, 08:00 (Japan)**

- 19:00 – 19:50      **Keynote lecture #2** by Dr. J.R. Buchanan, Jr. (Naval Nuclear Laboratory)  
Session Chair: Gretar Tryggvason (Johns Hopkins University)  
Quantitative validation of gas-liquid flow regime transition using Eulerian-Eulerian CFD models  
J.R. Buchanan, Jr., C.E. Clifford, B.M. Waite, T.S. Worosz, and M.D. Zimmer (*Naval Nuclear Laboratory*)
- 19:50 – 20:00      **Break**

**Tuesday, May 10, 2022, 20:00 (US EDT); Wednesday, May 11, 2022, 09:00 (Japan)**

- Session T3: Drag Reduction**, Session Chairs: Steven Ceccio (University of Michigan) and Yuichi Murai (Hokkaido University)
- 20:00 – 20:20      Interactions between microbubble clouds and turbulent vortical coherent structures on a flat vertical plate  
Hyun Jin Park, Daichi Saito, Yuji Tasaka, Yuichi Murai (*Hokkaido University*)
- 20:20 – 20:40      Bubbly drag reduction promoted by generating void waves in high-speed turbulent channel flows  
Taiji Tanaka, Hyun Jin Park (*Hokkaido University*), Yoshihiko Oishi (*Muroran Institute of Technology*), Yuji Tasaka, Yuichi Murai (*Hokkaido University*), and Chiharu Kawakita (*National Maritime Research Institute*)
- 20:40 – 21:00      Application of variable interval time averaging method to waveform of wall shear stress in bubbly channel flow  
Yoshihiko Oishi (*Muroran Institute of Technology*), Hyun Jin Park, Yuichi Murai, Yuji Tasaka (*Hokkaido University*), and Hideki Kawai (*Muroran Institute of Technology*)
- 21:00 – 21:20      Air entrainment and bubble generation by ventilated hydrofoils for ship drag reduction  
Ichiro Kumagai, Takahiro Tsukahara (*Meisei University*), and Yuichi Murai (*Hokkaido University*)
- 21:20 – 21:30      **Break**

**Tuesday, May 10, 2022, 21:30 (US EDT); Wednesday, May 11, 2022, 10:30 (Japan)**

- Session T4: Advanced Instrumentation and Measurement Techniques**, Session Chair: Matteo Bucci (Massachusetts Institute of Technology)
- 21:30 – 21:50      Application of PIV for virtual mass coefficient measurement  
Alexander Duenas, Qiao Wu, and Wade Marcum

- 21:50 – 22:10 Towards direct measurement of interface momentum transfer  
Charles Fort, Eirini Florou, and Philippe M. Bardet (*George Washington University*)
- 22:10 – 22:30 Visualization of the two-phase flow quench behavior using image processing technique  
Yue Jin, Arunkumar Seshadri, and Koroush Shirvan (*Massachusetts Institute of Technology*)
- 22:30 – 22:50 3-D measurements of optically opaque multiphase flows using limited angle X-ray tomography  
Nicholas Lucido, Harish Ganesh, and Steven Ceccio (*University of Michigan*)
- 22:50 – 23:10 Newly developed method for the liquid thin-film thickness measurement by using optical-fiber-based reflective probe  
Yuki Mizushima (*Shizuoka University*)

**Wednesday, May 11, 2022, 08:00 (US EDT); 21:00 (Japan)**

- 08:00 – 08:50      **Keynote lecture #3** by Prof. Tomio Okawa (The University of Electro-Communications)  
Session Chair: Ichiro Kumagai (Meisei University)  
Possible roles of global bubble coalescence in causing OSV and DNB in subcooled flow boiling  
Tomio Okawa and Nguyen Thanh Binh (*The University of Electro-Communications*)
- 08:50 – 09:00      **Break**

**Wednesday, May 11, 2022, 09:00 (US EDT); 22:00 (Japan)**

**Session W1: CHF and Boiling Heat Transfer**, Session Chair: Wade Marcum (Oregon State University)

- 09:00 – 09:20      Critical heat flux studies for accident tolerant fuel cladding material surfaces  
Hwasung Yeom, Woohyun Jung, Cole Dunbar (*University of Wisconsin-Madison*), Hangjin Jo (*POSTECH*), Kumar Sridharan and Michael Corradini (*University of Wisconsin-Madison*)
- 09:20 – 09:40      Assessing the advancement of multiphase CFD applicability to critical heat flux modeling for PWR fuel design  
Jinyong Feng, Zachary Skirpan, Emilio Baglietto (*Massachusetts Institute of Technology*), and Igor A. Bolotnov (*North Carolina State University*)
- 09:40 – 10:00      Experimental insights on the enhancement of the liquid heat transfer during nucleate boiling  
Gustavo Matana Aguiar, Bren Phillips, and Matteo Bucci (*Massachusetts Institute of Technology*)
- 10:00 – 10:20      Mechanism and implication of Gamma radiation on two-phase flow dynamics  
Koroush Shirvan (*Massachusetts Institute of Technology*)
- 10:20 – 10:30      **Break**

**Wednesday, May 11, 2022, 10:30 (US EDT); 23:30 (Japan)**

**Special Session: Reports on Nationwide Research Programs on Multiphase Flows**

- Session Chair      Steven Ceccio (University of Michigan)
- 10:30 – 11:00      Current multiphase flow research activities in Japan and the U.S.  
Yuichi Murai (*Hokkaido University*), Gretar Tryggvason (*Johns Hopkins University*)

**Wednesday, May 11, 2022, 19:00 (US EDT); Thursday, May 12, 2022, 08:00 (Japan)**

**Session W2: Two-Phase Flow in Rod Bundle, Session Chair: Kazuyasu Sugiyama (Osaka University)**

- 19:00 – 19:20 Measurement of local void fraction of air water flow in the 8X8 rod bundle using high-resolution Gamma ray tomography  
Taehwan Ahn, Julio Diaz (*University of Michigan*), Robert Adams (*University of Michigan and ETH Zürich*), Victor Petrov, and Annalisa Manera (*University of Michigan, ETH Zürich, and Paul Scherrer Institut*)
- 19:20 – 19:40 Countercurrent flooding in a rod bundle partially filled with particles  
Raito Goda, Akio Tomiyama (*Kobe University*), and Masahiro Kawaji (*City University of New York–City College*)
- 19:40 – 20:00 Gas-liquid two-phase annular flow across grid spacer with vanes in 3×3 rod bundle channel  
Akimaro Kawahara, Yukihiro Yonemoto, and Hiroto Tazoe (*Kumamoto University*)
- 20:00 – 20:10 Break**

**Wednesday, May 11, 2022, 20:10 (US EDT); Thursday, May 12, 2022, 09:10 (Japan)**

**Session W3: Multiphase Flow Modeling and Simulation - III, Session Chair: Kosuke Hayashi (Kobe University)**

- 20:10 – 20:30 Multiphase turbulence modeling using sparse regression and gene expression programming  
Sarah Beethama (*Oakland University*) and Jesse Capecelatro (*University of Michigan*)
- 20:30 – 20:50 On the oscillation-enhanced shear-thinning effect on a sphere motion in power-law fluid  
Kazuyasu Sugiyama, Xianping Zhang (*Osaka University and RIKEN Center for Advanced Photonics*), and Tomoaki Watamura (*Kyoto Institute of Technology and RIKEN Center for Advanced Photonics*)
- 20:50 – 21:10 A model of annular flow interfacial area concentration for 3-D Two-Fluid Model  
Guanyi Wang and Mamoru Ishii (*Purdue University*)
- 21:10 – 21:30 Quantifying model form uncertainty in MCFD simulations of bubbly flows with physics informed machine learning  
Yang Liu (*Argonne National Laboratory*), Nam Dinh (*North Carolina State University*), Xiaodong Sun (*University of Michigan*), and Rui Hu (*Argonne National Laboratory*)
- 21:30 – 21:40 Break**

**Wednesday, May 11, 2022, 21:40 (US EDT); Thursday, May 12, 2022, 10:40 (Japan)**

**Closing Remarks**

Session Chair      Xiaodong Sun (University of Michigan)

21:40 – 22:10      Closing Remarks  
Mamoru Ishii, Honorary Chair  
Steven Ceccio, General Chair  
Yuichi Murai, General Co-Chair  
Seminar Chair for the 13<sup>th</sup> Japan-US STPF