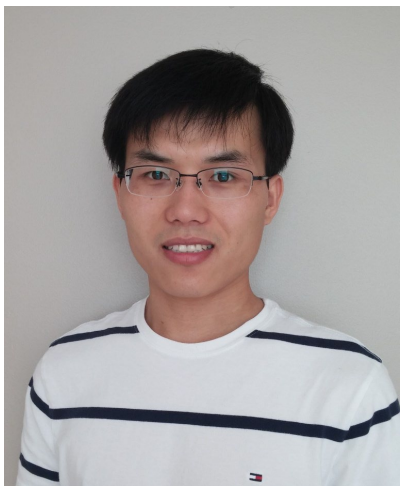
I²CNER Webinar

International Institute for Carbon-Neutral Energy Research (WPI-I²CNER)
Kyushu University

Title **Quantifying pore-scale interactions of multiphase flow in porous media using microfluidics and advanced flow diagnostics**



Speaker Prof. Yaofa Li
Department of Mechanical & Industrial Engineering at Montana State University

Time& Date 9:00 AM(JST), Wednesday, May 11th, 2022

Abstract

Multiphase flow in porous media are central to a range of applications in the heat and energy sector. These applications include but not limited to, CO_2 capture and storage (CCS), fuel cells and enhance oil recovery (EOR). Understanding the underlying physics of these complex flows at microscale is required for understanding, guiding and improving those real operations. Recent advances in micro/nanofluidics and laser-based flow diagnostics such as microscopic particle image velocimetry (micro-PIV) have provided great experimental tools for such purpose. In this talk, I will highlight the use of microfluidics, micro-PIV and epi-fluorescent microscopy to study and quantify a few pore-scale phenomena in porous media, which challenges traditional predictive models and meanwhile provides new insights for the development of new advanced models.

Specifically, I will talk about two types of measurements we have done: a millimeter-scale measurement focusing on the interface dynamics and displacement patterns under various reservoir-relevant conditions, and a pore-scale measurement that highlights the impact of the Haines jumps and the associated inertial effect. The millimeter-scale measurement suggest that final CO_2 saturation first decreases and then increases logarithmically with Ca within the capillary and viscous-fingering regimes, respectively, with a minimum occurring during regime crossover. Statistical analysis of the interfacial movements revealed that pore-scale events are controlled by their intrinsic dynamics at low Ca, but overrun by the bulk flow at high Ca. In the pore-scale measurement, when CO2 displaced water in a hydrophilic micromodel (i.e., drainage), unstable capillary fingering occurred and the pore flow was dominated by successive pore-scale burst events (i.e., Haines jumps). When the same experiment was repeated in a nearly neutral wetting micromodel (i.e., weak imbibition), flow instability and fluctuations were virtually eliminated, leading to a more compact displacement pattern. Energy balance analysis indicates that that kinetic energy is a disproportionately smaller contributor to the energy budget. These results provide unique insights into the underlying flow dynamics during multiphase flow in porous media. Additionally, I will briefly talk about a couple of ongoing projects in my group, including the design of a microfluidic pressure sensor for capillary pressure measurement, and the quantification of mineral dissolution in porous media.

About the Speaker

Dr. Yaofa Li is currently an Assistant Professor in the Department of Mechanical & Industrial Engineering at Montana State University. He obtained his B.S. from the University of Science and Technology of China in 2009 and Ph.D. from Georgia Tech in 2015. Prior to joining MSU, He was Postdoctoral Research Associate at the University of Notre Dame, where his research was partially supported by I2CNER. Dr. Li's research interest focuses on developing experimental studies of thermal-fluid problems primarily at microscopic scales with applications in thermal sciences, multiphase flow, and mineral dissolution in porous media. He is recent recipient of the NSF Career Award and the Doctoral New Investigator Award from American Chemical Society Petroleum Research Fund.

Registration https://zoom.us/webinar/register/WN_BvLWkUzTRteNLSPPiBmIww

Host Prof. Kenneth T. Christensen, Illinois Tech

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