# 25th I$^2$plus Seminar

## Schedule: 11:00 ~, 23rd Mar. 2018

## Place: ME Meeting Room (2F, Bldg #2, Noda)

## Speaker: Prof. Prashant VALLURI

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# Multiphase Flows @ Ultra-high Resolutions: World of Unparalleled Scientific Beauty

**Abstract:** It has been recognised that direct numerical simulations (DNS) of multiphase flows, coupled with targeted theoretical methods such as stability analyses and specific large-scale experiments, offer the most accurate solutions for these flows. But until recently, rigorous DNS were always deemed computationally expensive and unapproachable. DNS was more common for single-phase flow problems than for multiphase flows, that too at low flowrates. However, with considerable advancements in processor speeds, efficient supercomputing architectures and parallelised numerical algorithms – our group in Edinburgh along with collaborators in Europe and USA has shown that super-fast DNS of two-phase flows can provide relevant engineering solutions and at the same time reveal, remarkable physical phenomena that were hitherto unknown.

In this talk, I will show this by two specific examples: phase-change (recently published in Nature Communications [1] and previously in the Journal of Fluid Mechanics [2] and Physics of Fluids [3]) and stratified flows (recently published in Physics Review Fluids [4], Physics of Fluids [5] and Journal of Fluid Mechanics [6]). By using our state-of-the-art ultra-high resolution two-phase flow solver called TPLS (opensource available: https://sourceforge.net/projects/tpls/), backed up with fundamental theoretical analysis on instabilities, and advanced experimentation, I will present our latest findings. We have developed this solver, specifically for supercomputing architectures and we use the UK's national supercomputer ARCHER for our calculations.

Our rigorous calculations (also validated against experiment and theory) have shown: a) Previously unknown azimuthal currents in complex evaporating droplets [2], b) These azimuthal currents drive segregation [1] of components in binary liquid mixtures which in turn impacts heat-transfer efficiencies in phase-change applications [3], c) New 3D [6] and 2D [4, 5] wave behaviour in stratified co-current and counter-current gas-liquid flows, d) The wave behaviour impacts the operability limits of equipment such as pipelines and channels and separation columns.

**References**

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3. Sáenz, P. J. et al., On phase change in Marangoni driven flows and its effects on the hydrothermal-wave instabilities, Phys. Fluids 26, 024114 (2014).
4. Lavalle, G. et al., Ultraefficient reduced model for countercurrent two-layer flows, Phys. Rev. Fluids, 2, 014001 (2017).
5. Schmidt, P. et al., Linear and nonlinear instability in vertical counter-current laminar gas-liquid flows, Phys. Fluids 28, 042102 (2016).
6. Ó Náraigh, L. et al., Linear instability, nonlinear instability and ligament dynamics in three-dimensional laminar two-layer liquid- liquid flows, J. Fluid Mech. 750, 464 (2014).

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