**ABSTRACT**

**Computational Method**
- A Lagrangian approach to solve phase transport in porous media
- A particle represents a phase (physical particles)
- Particles can carry various properties such as composition
- It is different from deterministic particle methods such as SPH
- Saturation is a local statistical property
- Physical particle evolution is approximated by a stochastic process
- Motivation: natural modeling framework for complex processes

**Applications**
- Numerical simulation framework for CO₂ sequestration in subsurface formations. The problem involves complex non-equilibrium processes:
  - Dissolution of CO₂ in brine
  - Chemical reactions
  - Trapping of CO₂
- SPM is a rigorous framework that can deal with non-equilibrium phenomena based on:
  - Statistical information from pore scale physics
  - Joint PDFs, correlation time and length scales

**MATHEMATICAL MODEL AND SOLUTION ALGORITHM**

**Validation for 2-Phase Darcy Flow: An Example of a Stochastic Model**

**Algorithm**
- **Flow Solver-FVM**
- **Stochastic rule for Particle Velocity**
- **Particle Movement**
- **Saturation Estimation**

**1D Test Case: Buckley-Leverett Problem**
- Saturation of injected phase after t=0.25s for two grid spacings Vₘᵣ,=1m/s, C₀=0.

**1D Test Case: Buckley-Leverett Problem with Capillary Pressure**
- **Constant C**
- Saturation of injected phase after t=0.25s. Dₓ=0.001. dₓ=0.01.

**Non-constant C**
- C(S) = \( \frac{C(1-S)^2}{3(1-S)^2} \)
- Saturation of injected phase after t=0.25s. Dₓ=0.001. dₓ=0.01.

**2D Test Case: Quarter-Five Spot Configuration**

**Homogeneous Permeability Field**
- Simulation results after 0.25 PVI
- Grid =100*100
- In the scatter plot, blue particles are injected in the domain initially filled with red particles.
- Dₓ=0.01 Vₘᵣ, C₀=0

**Heterogeneous Permeability Field**
- Simulation results after 0.25 PVI
- Grid =100*100
- In the scatter plot, blue particles are injected in the domain initially filled with red particles.
- Dₓ=0.01 Vₘᵣ, C₀=0

**OUTLOOK**
- Transporting particles with more complex rules that are consistent with the pore scale dynamics. The rules for particle movement can be provided by pore network simulations
- Using SPM for the problem of CO₂ sequestration in subsurface formations: A numerical tool to study complex processes; dissolution of CO₂ in brine, reaction, trapping etc.
- Extract effective models for finite volume simulator