

Research Interests

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Standard porous medium model

$$\frac{\partial}{\partial t} (\epsilon^\alpha \rho^\alpha \omega^{\iota\alpha}) = -\nabla \cdot (\mathbf{j}^{\iota\alpha} + \epsilon^\alpha \rho^\alpha \omega^{\iota\alpha} \mathbf{v}^\alpha) + \mathcal{I}^{\iota\alpha} + \mathcal{R}^{\iota\alpha} + \mathcal{S}^{\iota\alpha}$$

$$\frac{\partial}{\partial t} (\epsilon^\alpha \rho^\alpha) = -\nabla \cdot (\epsilon^\alpha \rho^\alpha \mathbf{v}^\alpha) + \mathcal{I}^\alpha + \mathcal{S}^\alpha$$

Standard closure relations, Darcy's Law:

$$\mathbf{q}^\alpha = \epsilon^\alpha \mathbf{v}^\alpha = -\frac{\mathbf{k}^\alpha}{\mu^\alpha} \cdot (\nabla p^\alpha + \rho^\alpha g \nabla z)$$

Pressure-Saturation Relation:

$$S^\alpha = f(p^\beta(t)), \text{ for } \beta = 1, \dots, n_f$$

Saturation-Conductivity Relation:

$$k^{r\alpha} = f(S^\beta(t)), \text{ for } \beta = 1, \dots, n_f$$

Example Areas of Interest

1. Deriving alternative models to the standard model that respond to some of the open issues
 - (a) lack of thermodynamic constraints
 - (b) hysteretic closure relations
 - (c) no specific account for interfacial areas
 - (d) assumptions of local physical and chemical equilibrium
 - (e) lack of direct connections between fundamental microscale notions and macroscale equations

2. Development and application of pore-scale models for a variety of uses

- (a) closure relations for standard models: capillary pressure, saturation, permeability; viscous coupling; tortuosity; dispersion, dissolution
- (b) rules for network models
- (c) prediction and correlation of physical parameters
- (d) closure relations for evolving models, such as pressure-saturation-interfacial areas, dynamic p - S - k relations, etc

3. Development of improved macroscale models for interphase mass transfer

- (a) NAPL dissolution and fingering models, upscaling
- (b) solute sorption from fluid phase to solid particles, including multi-scale approaches
- (c) comparison of evolving models to experimental data sets

4. Numerical methods for solving multiphase continuum models

- (a) solution algorithms, e.g., split-operator methods
- (b) adaptive, higher-order temporal integration

- (c) locally, mass conserving discretization schemes, such as mixed finite element methods and discontinuous Galerkin methods
- (d) spatially and temporally adaptive methods
- (e) efficient solution of large, sparse nonlinear systems of algebraic equations
- (f) optimization methods for optimal design

5. Computational science issues

- (a) object-oriented methods
- (b) problem solving environments
- (c) parallel implementations of algorithms

6. Remediation technology development

- (a) dense brine behavior in heterogeneous systems
- (b) complex mixture behavior
- (c) development of suitable simulator
- (d) optimal design

7. Stochastic aspects

- (a) effects of heterogeneity on transport phenomena
- (b) stochastic computation
- (c) representation of heterogeneity