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Lattice Boltzmann study on viscous and inertial effects on liquid-gas flow in porous media

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Statement of the Problem: Liquid-gas two phase flow in porous media has attracted tremendous theoretical and industrial interests over the past decades. To circumvent to resolve the complex porous structures, a representative-elementary-volume (REV) scale is usually proposed to characterize two-phase flow averaged features in porous media. Generally, flow in porous media at the REV scale is described by Darcy's law. However, this simple formula is inaccurate for high flow-rate problems where inertial force plays a significant role. Importantly, viscous effects of flow cannot be treated negligibly small nearby solid boundaries.

Purpose of the study: The purpose of this study is to reveal the interplay among the forces characterized by the Darcy, Forchheimer and Brinkman terms, and gain a deeper understanding of liquid-gas two phase flow and mass transfer with inertial and viscous effects in porous media.

Methodology & Theoretical Orientation: In this study, we develop a lattice Boltzmann (LB) model to numerically study such complex transport phenomena. We will propose a double-distribution-function LB model to simulate flow of the liquid and gas phases at the REV scale, respectively and also describe the corresponding saturation distribution. Different from previous works, our LB framework will include viscous (by Brinkman term) and inertial forces (by Forchheimer term) and reveal the rich flow features under these compounding effects.

Findings: The LB model proposed in this study can be an efficient and useful tool to study complex two-phase flow and mass transfer in porous media.

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