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Calibration of stress–jump conditions for arbitrary flow directions in fluid–porous systems

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The coupling of Stokes and Darcy's equations for simulating flow in porous media and adjacent free-flow regions has led to various coupling conditions being developed. Notably, Angot et al. [Phys. Rev. E 95 (2017) 063302-1–063302-16] introduced stress jump conditions that accommodate arbitrary flow directions at the interface. These conditions incorporate a friction tensor whose values remain unknown. While calibration has been achieved for one-dimensional flow, validation of the stress jump conditions in two-dimensional scenarios remains absent.
Through comprehensive analysis of multiple porous medium configurations and flow regimes, we determine the unknown parameters in these conditions by comparison with reference solutions derived from pore-scale simulations. Our investigation compares various optimization methods for calibration purposes. Despite having three unknown parameters, we demonstrate that leveraging the porous-medium structure allows reduction to a two-dimensional problem without compromising model performance. Finally, a regional sensitivity analysis reveals how susceptible the simulation results are to variations in the friction tensor components.

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