Effects of slip on highly viscous thin-film flows inside a vertical tube

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Viscous liquid film flows in a tube arise in numerous industrial and biological applications, including the transport of mucus in human airways. Previous modeling studies have typically used no-slip boundary conditions, but in some applications the effects of slip at the boundary may not be negligible. We derive a long-wave model based on lubrication theory which allows for slippage along the boundary. Linear stability analysis verifies the impact of slip-length on the speed, growth rate, and wavelength of the most unstable mode. Nonlinear simulations demonstrate the impact of slip-length on plug formation and wave dynamics. These simulations are conducted for flows driven by gravity, core flow, or a combination of the two.