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Active control of thermomagnetic forced convection in flat microchannels via induced magnetic fields

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Heat transfer enhancement techniques in microfluidics have significant limitations: low Reynolds numbers prevent turbulent mixing, and changing the channel shape is a difficult technological undertaking. Magnetic fluid as a heat carrier enables heat transfer augmentation via an external non-uniform magnetic field without modifying channel geometry.

The influence of an induced magnetic field on forced convection in a microchannel was investigated numerically. High-permeability sinusoidal elements, characterized by their wavelength (λ) and amplitude, were positioned near the channel walls in an external uniform field normal to the channel plane to serve as the source of magnetic non-uniformity. Results showed that magnetic field gradients cause the formation of recirculation regions (Fig. 1), which augment convection. An optimal configuration of the sinusoidal components was determined, ensuring the maximum heat transfer enhancement. Additionally, the pressure drop penalty associated with enhanced fluid mixing was evaluated. The impact of external field magnitude on convection was also investigated.

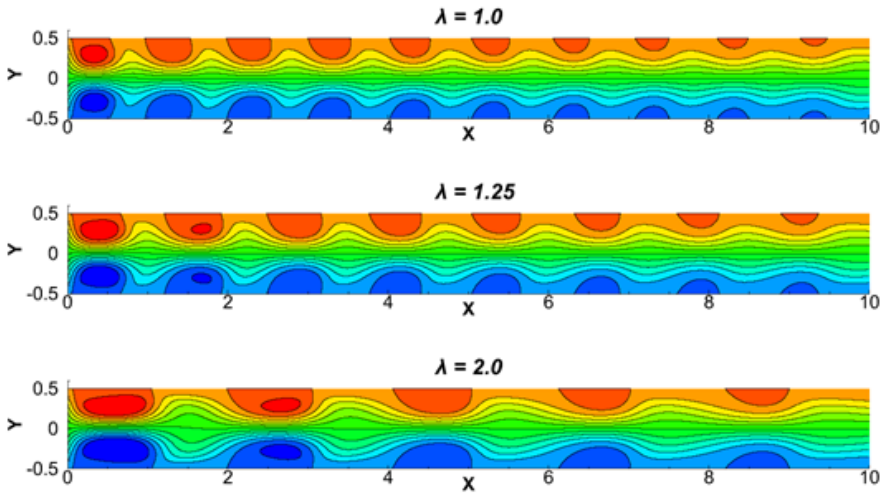

Figure 1: Stream lines demonstrate the flow structure at various wavelengths (λ).

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