

# Magnetohydrodynamic Micromixing

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Efficient mixing of fluids in the low Reynolds number flows typical of micro total analysis systems ( $\mu$ TAS) and lab-on-a-chip technologies requires novel approaches. The lack of turbulence and the difficulty of incorporating moving stirrers into microdevices has inspired investigation of other mixing mechanisms. Magnetohydrodynamic (MHD) forces provide a pumping mechanism in conductive liquids such as biological fluids, and have recently been utilized in the design of suitable electrode patterns for micromixing devices [1].

In this paper the effects of an alternating-current MHD force upon fluid in a cylindrically-symmetric channel are examined. Suitable approximations reduce the full MHD equations to a Poisson equation in the channel cross-section. Solutions of this model are shown to accurately match experimental observations of fluid circulation in an annular channel [2]. Analytical solutions for the fluid velocity are zero at the walls (no-slip boundaries) and have a maximum near the centre of the channel. As a result of this velocity profile, fluids initially separated into semicircular portions of the annular channel (Fig. 1) are forced by the MHD pumping to pass through each other (Fig. 2). The length of the interface between the fluids is described by a simple iteration map, and is shown to grow linearly in time, thus enhancing mixing. No special patterning of electrodes is necessary, and the simplicity of this approach makes it attractive as a general-purpose micromixing mechanism. Further work includes modeling the effects of molecular diffusion and experimental verification of the model predictions.

## References

- [1] Bau H.H., Zhong J. and Yi M., “A minute magneto hydro dynamic (MHD) mixer,” *Sensors and Actuators B*, in press.
- [2] West J. et al., “Annular magnetohydrodynamic actuation for cyclical chemical reactions,” submitted to NanoTech 2001.

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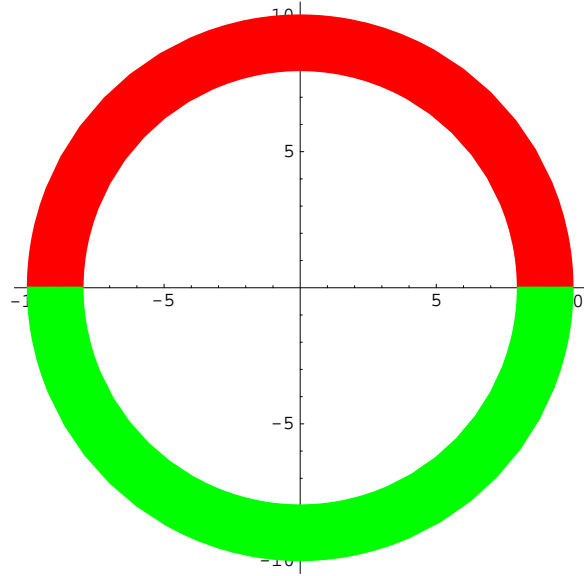


Figure 1: Initially separated fluids.

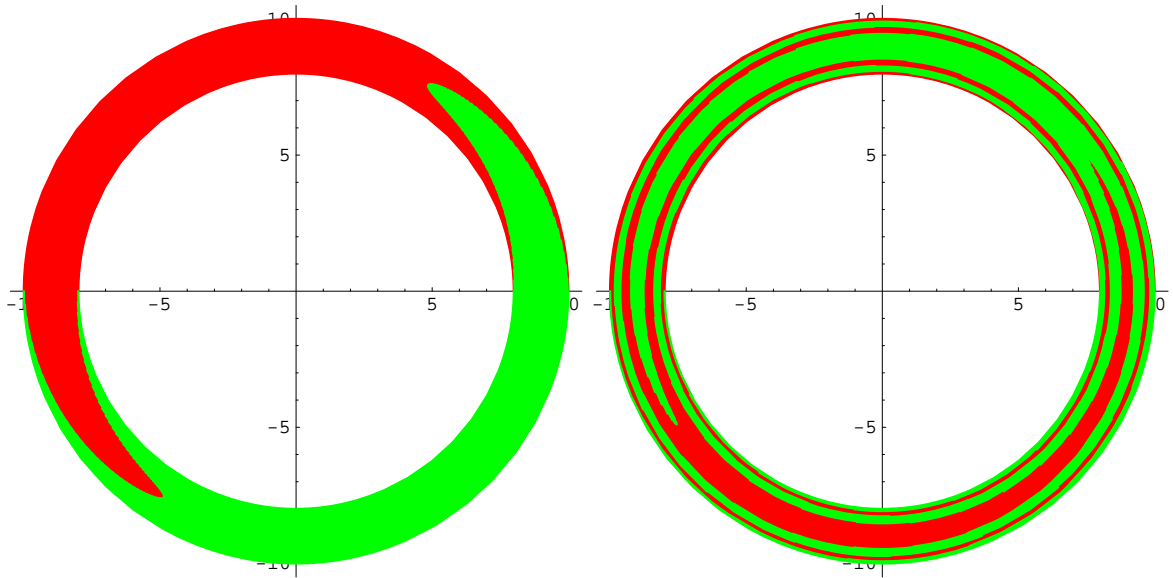


Figure 2: Growth of interface at later times.