FMRC Fluid Mechanics Seminar Series

Characterization and Modeling of Bio-inspired Swimming Microrobots

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Abstract: Autonomous micro-swimming robots can be utilized to perform specialized procedures such as in vitro or in vivo medical tasks and micro manipulation. Nature provides guidelines for a conceptual design of swimming microrobots, which is composed of a body that carries the payload, control and actuation mechanisms, and a long flagellum, which can be either a whip-like tail-actuator that deforms and propagates planar waves similar to spermatozoa, or a rotating rigid helix similar to many bacteria, such as E. Coli.

Motion of micro swimmers in confined geometries such as channels is important due to its relevance in in vivo medical applications such as minimally invasive surgery and drug delivery. Here, swimmers with diameters 0.8 mm and lengths 2 to 3 mm are produced with a 3D printer and cylindrical Nd2Fe14B magnets are placed inside the bodies. Rotating external magnetic field is used for the actuation of artificial swimmers. Different body and tail geometries are produced and experiments are conducted with a glycerol filled circular channel. Results demonstrate that decreasing channel diameter directly affects the forward motion of the swimmer due to the increasing drag. It is observed that step-out frequency, which defines maximum frequency at which the swimmer can establish a synchronous rotation with the external magnetic field, depends on the geometry of the swimmer and the channel diameter. There are significant differences between low and high frequency motion and forward and backward swimming. Longer tails enable higher forward velocities in high frequencies than backward ones, whereas forward and backward velocities are approximately the same at low frequencies. Furthermore backward motion is more stable than the forward one; at high frequencies, swimmers travel almost at the center of the channel for backward motion, and follow a helical trajectory near the wall during the forward motion. According to simulation results there is a flow which is induced by the rotation of the swimmer rotation that affects the swimmer's trajectory.

Biography: Assoc. Prof. Serhat Yesilyurt, received the B.Sc. degree in nuclear energy engineering from Hacettepe University, Ankara, Turkey, in 1986, and the M.Sc. and Ph.D. degrees in nuclear engineering from Massachusetts Institute of Technology, Cambridge, MA, USA, in 1991 and 1995, respectively. He has been a faculty member at Sabanci University, Istanbul, Turkey, since 2002.