Abstract Submitted
for the DFD05 Meeting of
The American Physical Society

Bending Leaves and Flapping Flight: Transitions in Flow-Body Interaction Problems SILAS ALBEN, Harvard University — The coupled motion of fluids and solids in contact is common in the biological world, and leads to unexpected phenomena in theoretical mechanics. I will address two model problems in this area, both of which arose from experiments. The first problem asks: How can a flexible body reduce its drag by bending in a flow? We specialize to the case of a uniform elastica immersed in a steady planar flow, and find a transition from the quadratic growth of drag with flow speed typical of rigid bodies to a much-reduced 4/3-power law. We find also that the body and wake assume a unified, parabolic form. An asymptotic argument explains the governing phenomenon: the formation of a "tip region" on the fiber, which gives rise to global self-similarity. The second problem, initiated by a recent experiment by Vandenberghe, Zhang, and Childress, asks: Under what conditions does a flapping foil spontaneously locomote? We find that, at sufficiently large "frequency Reynolds number," unidirectional locomotion emerges as an attracting state for an initially nonlocomoting body. Locomotion is generated in two stages: first, the fluid field loses symmetry by an instability similar to the classical von Karman instability; and second, precipitous interactions with previously shed vortical structures "push" the body into locomotion. Body mass and slenderness play central and unexpected roles in each stage.

Silas Alben
Harvard University

Date submitted: 09 Aug 2005 Electronic form version 1.4