Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Flapping dynamics of an inverted flag[1] DAEGYOUM KIM, JULIA COSSE, MORTEZA GHARIB, California Institute of Technology — The dynamics of an inverted flag are investigated experimentally in order to find the conditions under which flapping can occur. In contrast to a general flag with a fixed leading edge and a free trailing edge, the inverted flag of our study has a free leading edge and a clamped trailing edge. The behavior of the inverted flag can be classified into three regimes based on its bending stiffness. Two quasi-steady regimes, straight mode and fully deflected mode, are observed, and limit-cycle flapping mode with large amplitude appears between the two quasi-steady regimes. Bistable states are found in both straight to flapping mode transition and flapping to deflected mode transition. The effect of mass ratio, relative magnitude of flag inertia and fluid inertia, on the bending stiffness range for flapping is negligible unlike the instability of the general flag. Because of unsteady fluid force, a flapping sheet can produce several times larger elastic strain energy than a sheet of the deformed mode, improving the conversion of fluid kinetic energy to elastic strain energy. According to the analysis of leading-edge vortex formation process, the time scale of optimal vortex formation correlates with efficient conversion to elastic strain energy during bending.

[1]This research is supported by the Gordon and Betty Moore Foundation.

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Date submitted: 31 Jul 2013 Electronic form version 1.4