Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

The oscillatory dynamics of whiskers: nonlinear modal coupling vs. fluid coupling THOMAS L. JANSSEN, Northwestern University, SHAYAN HEYDARI, RAJEEV JAIMAN, University of British Columbia, MITRA J. Z. HARTMANN, NEELESH A. PATANKAR, Northwestern University — Previous work has shown that rats use their whiskers to localize airflow sources. A single whisker bends primarily in the direction of flow and vibrates around its deflected position. The vibrations have components both in and out of the bending plane. This dynamic response is surprising because galloping or vortex induced vibrations are not expected for thin beams with circular cross-sections at low Reynolds numbers (Re). We hypothesized that the dynamics could result either from geometric nonlinearities that lead to coupled structural bending modes, or from nonlinear fluid-structure interactions at low Re, or from a combination of both effects. To investigate the effect of coupled bending modes, we developed a model for a thin, long, and stiff cantilever beam under the influence of fluid loading at low Re. We include terms to capture hardening nonlinearity due to stored potential energy in bending, inertia nonlinearity due to kinetic energy of axial motion, as well as a quasi-static low Re drag model to provide simplified fluid forcing. To separately investigate the effects of nonlinear fluid coupling, we consider a second model in which the fluid is fully resolved but the beam is simplified by considering only linear modes. A comparison between these two studies will be presented. Ultimately, our goal is to combine the two techniques discussed here to fully resolve fluid-structure interactions that capture nonlinearities due to both structural and fluid phenomena.

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Date submitted: 06 Aug 2020 Electronic form version 1.4