Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Stiffness Modulation of Rayed Fins by Curvature[1] KHOI NGUYEN, Yale University, NING YU, Brown University, MADHUSUDHAN VENKADESAN, Yale University, MAHESH BANDI, Okinawa Institute of Science and Technology, SHREYAS MANDRE, Brown University — Fishes with rayed fins comprise over 99% of all extant fish species. Multifunctional use of fins, from propulsion to station holding, requires substantial modulation of stiffness. We propose that fishes stiffen the fin by curving it transverse to its length. This effect is similar to stiffening a dollar bill by curling it because of curvature-induced coupling of out-of-plane bending with in-plane stretching. Unlike a piece of paper, rayed fins are a composite of rays and membranes. We model this as parallel elastic beams (rays) with springy interconnections (membranes). Our analysis shows that the key parameters stiffening the fin are the ray anisotropy to bending, the misalignment of principal bending directions of adjacent rays, and the membrane elasticity. The composite fin stiffens when the principal bending directions of adjacent rays are misaligned due to fin curvature, which necessarily causes the membrane to stretch. Unlike a homogenous thin sheet, composite rayed structures are able to mimic curvature-induced stiffening by using misaligned rays even if the fin appears geometrically flat. Preliminary radiographic evidence from the rays of fish fins supports such a mechanism.

[1]Funding by Human Frontier Science Program

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Date submitted: 01 Aug 2016 Electronic form version 1.4