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Abstract for an Invited Paper
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Collective Behavior of Hair, and Ponytail Shape and Dynamics.[1]

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I will discuss how we can build a mathematical model of the behaviour of a bundle of hair, comparing the results with experimental studies of the shape and dynamics of human ponytails. We treat the individual fibers as elastic filaments with random intrinsic curvature, in which the balance of bending elasticity, gravity, orientational disorder and inertia is recast as a differential equation for the envelope of the fibre bundle. The static elements of this work were first reported in R.E. Goldstein, P.B. Warren and R.C. Ball, Physical Review Letters 108, 078101 (2012). The compressibility of the bundle enters through an equation of state whose empirical form is shown to arise from a Confined Helix Model, in which the constraint of the surrounding hair is on a given fibre is represented as a confining cylinder. Using this model we find the ponytail shape is well fit with only one adjustable parameter, which is the degree to which the confining cylinders over fill space. The dynamics of driven vertical ponytail motion is well reproduced provided we introduce some damping, and we find the level of damping required is consistent with that arising from viscous drag of the lateral motion of the hair fibres through the interstitial air. Most of our match with experiment is achieved by approximating the fibre density of the ponytail to to be uniform across its cross-section, and to vary only length-wise. However we show that detail near the exit from a confining clamp (aka hairband) is only captured by computing the full cross-sectional variation.

[1]The work reported is joint with RE Goldstein (Cambridge UK) and PB Warren (Unilever Research).