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The sedimentation of flexible filaments: A buckling instability HARISHANKAR MANIKANTAN, DAVID SAINTILLAN, University of Illinois at Urbana-Champaign, LEI LI, SAVERIO SPAGNOLIE, University of Wisconsin-Madison — An elastic filament sedimenting in a viscous fluid can lead to complex deformations and dynamics due to the non-trivial interplay between gravity, viscous stresses and its internal elastic forces. One such dramatic case is the buckling of a flexible filament placed with its long axis parallel to gravity. Using slender-body theory for low-Reynolds number flows, we first show that a non-uniform tension is induced in the filament due primarily to a non-uniform shape and secondarily to non-local hydrodynamic interations. This tension acts to compress the filament in its leading half and can lead to a buckling instability in the highly flexible regime, which we characterize via a dimensionless elasto-gravitation number. We derive a dispersion relation that clearly illustrates this competing effect between tension and elastic rigidity, and also suggests that the instability travels as waves in the direction opposite gravity. We then turn to numerical simulations to verify this, and see that waves grow and travel as predicted. We also look at linear eigenmodes of the governing equation, and the mode shapes so obtained agree well with those observed in simulations.

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