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Coiling rods onto moving substrates MOHAMMAD JAWED, Massachusetts Institute of Technology, FANG DA, EITAN GRINSPUN, Columbia University, PEDRO REIS, Massachusetts Institute of Technology — We present results on the nonlinear patterns obtained when a thin elastic rod is deployed onto a moving substrate. Our experiments comprise an injector that deposits an elastomeric rod onto a conveyor belt, where it coils in a variety of nonlinear patterns, depending on the control parameters. The portion of the rod that is suspended between the injector and the point of contact with the belt can exhibit strong geometric nonlinearities that are a challenge for traditional analytical and numerical methods. We tackle this challenge by coupling our precision model experiments with cutting-edge simulation tools ported from the computer graphics community. By systematically exploring parameter space, we map out the basins of stability of the various nonlinear coiling patterns, which are then rationalized using a detailed energy balance. We give particular emphasis to the sinusoidal patterns that emerge from a straight-to-meandering instability that we find to be consistent with a Hopf bifurcation. Closed-form solutions are derived to describe the amplitude and wavelength of the meandering patterns. The excellent agreement between experiments, simulations and theory conveys the predictive ability of our tools to be used, upon scaling, in the original engineering applications that motivated this study: serpentines created from the coiling of carbon nanotubes (at the micron-scale) and the laying down of transoceanic undersea cables (at the kilometer-scale).

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