Shapes of a looped elastic ribbon under tension

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In three dimensional space, a thin elastic ribbon behaves like a developable surface, where its smooth deformation is mostly derived from out-of-plane bending deflections. A geometrically constrained ribbon may respond quite differently when subjected to external loadings. A simple experimentation of such processes is given by a paper strip that is looped and pulled. One finds that the loop either pops out (unfolds) or folds in on itself when it gets sufficiently tight. Here we study this seemingly very simple phenomenon in detail by combing experimental and theoretical approaches. We measure shape dynamics of this frustrated ribbon, and report various morphologies depending on relevant geometric parameters. We present an experimentally integrated phase diagram, which are physically interpreted using our numerical simulations based on a geometrically reduced ribbon model. We point out an essential role of the anisotropy of the bending elasticity that is inherent to thin strips and ribbons.