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Tension in rope coiling on a rotating plane

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Coiling of rope, fed from a height onto a rotating plane, progresses through a sequence of shapes, a hypotrochoid to an epitrochoid to a circle as frequency of plane increases. Feeding velocity controls the rate of length deposition on a plane and frequency of plane controls the rate of length transfer from a contact point, where rope first touches a plane. Formation of secondary loops of a hypotrochoid or an epitrochoid results from the faster deposition rate than the transfer rate. When these two rates are comparable, secondary loops disappear so the shape returns to a circle like in rope coiling on a static plane. In a reference frame corotating with rope, the Coriolis and centrifugal forces act only at the contact point, not extending to the portion of rope far above a rotating plane. For small deflection of rope, tension is inferred from the equations of motion with using the radius and frequency of a primary loop measured in experiments. Tension changes continuously at both the hypotrochoid-epitrochoid transition and the epitrochoid-circle transition, reminiscent of the features of a second order phase transition.

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