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Rope coiling on a rotating plane

Rope coiling on a static plane is a circle with full rotational symmetry. The more ordered shapes, hypotrochoids and epitrochoids, arise from the breaking of rotational symmetry induced by the rotation of a plane. Given the sufficiently slow plane frequencies, as feeding velocity is increased the shape deforms from a circle to an epitrochoid and eventually to a hypotrochoid. The onset of hypotrochoids is the equality of the inertial force, provided by feeding velocity, and the tension. Given the sufficiently fast feeding velocities, as plane frequency is increased the shape changes from a hypotrochoid to an epitrochoid and eventually to a circle. However the shape transitions caused by feeding velocity have the different characteristics from those caused by plane frequency. For the former, the force, associating with the bending energy per unit length, is continuous at the epitrochoid-circle transition but exhibits a jump at the hypotrochoid-epitrochoid transition. For the latter, such force shows a jump at both the epitrochoid-circle transistion and the hypotrochoid-epitrochoid transition. In a phase diagram the hypotrochoids occur in the regime of the large heights, fast feeding velocities, and slow plane frequencies. Circles appear at all heights with the slow feeding velocities and fast plane frequencies. Epitrochoids emerge in the intermediate regime between hypotrochoids and circles.

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