Using math to describe the spinning transition between the assemblage of fibers in yarn

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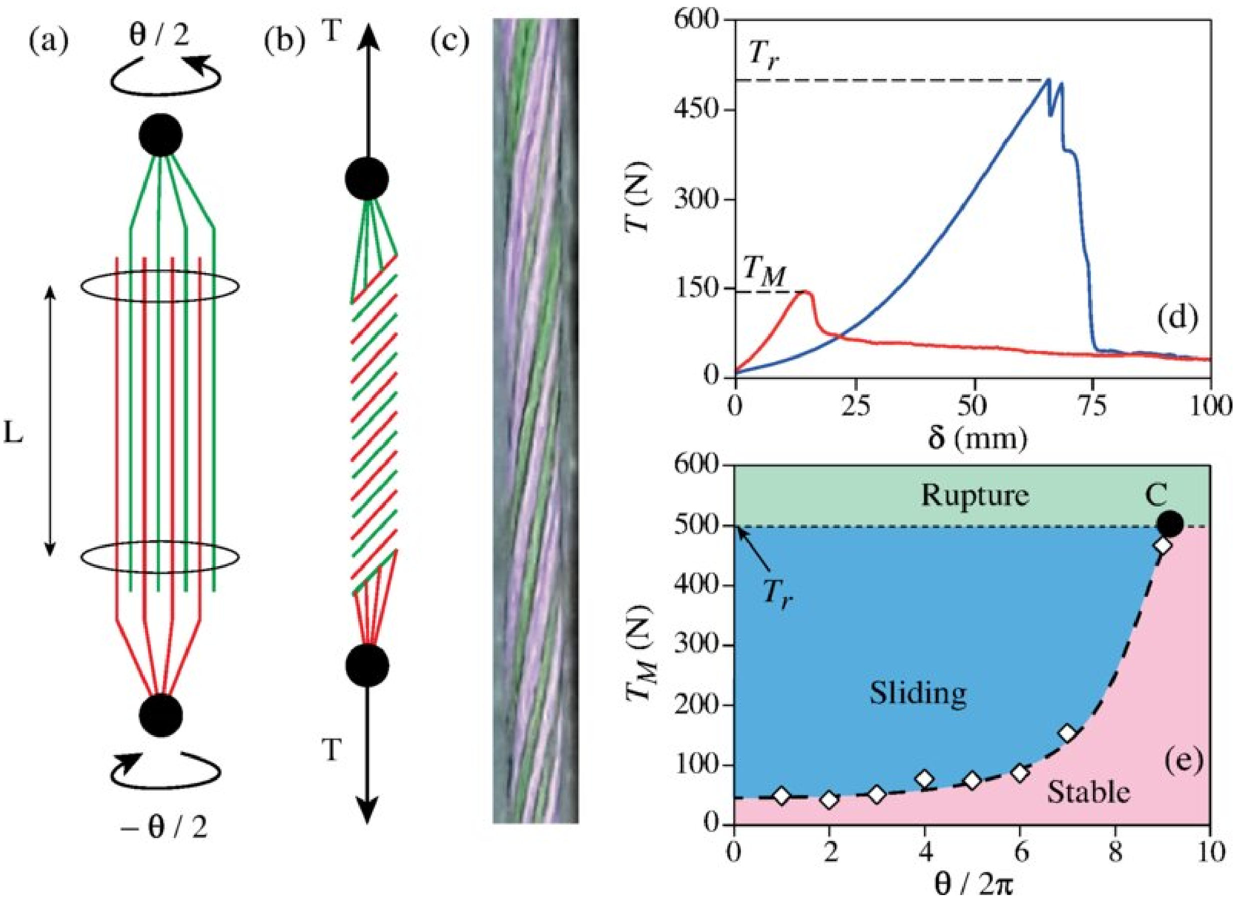

Credit: *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.128.078002

A pair of researchers from Universit´e Paris-Saclay, CNRS and Univ Rennes, CNRS, IPR, respectively, has used math to help describe the process involved when short strands of fiber are twisted into long stretches of yarn. In their paper published in the journal *Physical Review Letters,* Antoine Seguin and Jérôme Crassous describe how they used experiments and simulations to better understand the factors involved when fibers are twisted together.

Humans have been twisting short strands of fibers together to create long strands of rope or yarn for thousands of years, and while the overall process is well understood, the mathematics behind it has been rather sketchy. In this new effort, Seguin and Crassous have tackled the problem using a new approach, applying both experiments and simulations.

As several short fibers are twisted together, they become entwined, but that of course is not enough to keep them together. They hold together because of the friction involved. Pulling on the ends of a length of yarn forces the individual strands it is made of to push into each other, increasing the amount of friction and thereby its strength. But are there mathematical rules governing the process? What is the optimal number of fibers, for example, to ensure the strongest yarn? Or what degree of strength is given to the yarn by the degree of friction between two strands of fiber?

To find these answers, the researchers conducted multiple tests on different fibers twisted into yarns. They found that an increase in twists increased fiber binding strength—but only up to a point. Also, each type of fiber had its own breaking point. In creating simulations to more easily test different configurations, they also found that there was an optimal fiber radius for a given length of yarn and that yarn strength scaled with the exponential of the square of the twist angle.

In looking for commonalities, they discovered what they describe as the Hercules twist number—a parameter that describes the forces involved with twisting angle, a friction coefficient and the radius of the yarn. They also found that this number in general was proportional to the square of the numbers of twists applied, and had a critical value of 30. They also developed a formula for showing the optimal radius size for a given type of fiber.

More information: Antoine Seguin et al, Twist-Controlled Force Amplification and Spinning Tension Transition in Yarn, *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.128.078002.