Unravelling the mysteries of coiling ropes

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If you carefully lower a rope onto the floor it will probably form a neat coil. While most people wouldn't give this a second thought, an international team of physicists has done a series of experiments and numerical simulations to work out why. Their new insights into coiling could shed light on the behaviour of an important class of materials called "elastic ropes", which includes DNA molecules and structural reinforcing rods in buildings (Phys. Rev. Lett. 99 154302).

Neil Ribe at the University of Paris−7 and colleagues in Iran and the Netherlands used a reel powered by an electric motor to feed ordinary rope or thread down through a hole and onto a glass or paper plate below. The rate of descent and the distance between the reel and the plate could be changed, allowing the team to study coiling over a wide range of speeds and drop lengths. A second set of similar experiments looked at the coiling of soft strands of spaghetti.

Ribe told physicsworld.com that the team is the first to perform controlled lab experiments on coiling and their use of different materials allowed them to build up a comprehensive understanding of why some ropes coil and others don't.

According to Ribe, one surprise result is that the coiling always occurred at several different "frequencies" for fixed values of the feed rate and fall distance. These frequencies correspond to the vibrational modes of the nearly vertical upper part of the falling rope. They discovered that coiling occurs when any of these frequencies matches the angular frequency at which bottom end of the rope whirls into a coil.

The team were also able to describe their observations in a numerical model that treated coiling as a fine balancing act between elastic, gravitational and inertial forces acting on the rope. According to Ribe the model was able to reproduce the observed multi−frequency nature of coiling.

"This is an exciting paper, which details the many different coiling patterns in an elastic rope," says Herbert Huppert, a geophysicist at the UK's University of Cambridge who has an interest in such materials. "The agreement [between experiment and numerical model] gives confidence to the detailed and complex nature of this sub−field of highly nonlinear dynamical systems, in contrast to many other situations for which the description is at best qualitative. Many a physicist is going to enjoy playing with his pasta after reading this paper."

Everyday ropes are the simplest example of elastic ropes −− a class of materials that includes encompassing electrical cables, plant vines, DNA and steel rods. Elastic ropes can act as nonlinear dynamical systems, the behaviour of which can be very difficult to understand. Ribe and colleagues hope that their simple experiments will cast light on the complex nature of these common materials.
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