When nanotube dreams come true

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Nanotubes of carbon and related materials are more than long nanowires with excellent charge and thermal transport properties [1]. The constrained cylindrical volume inside, with diameters around 1 nm, may be filled with atoms or molecules that often arrange in a very different way than in free space. In this way, selenium or sulfur atoms may reconnect inside the nanotube to helical or linear chains that may become metallic [2]. Nanotubes even act as natural pressure containers that selectively drive particular chemical reactions, including a transformation of functionalized diamonoid molecules to a diamond nanowire inside a nanotube [3].

Recent interest in layered black phosphorus and other potential 2D phosphorene allotropes [4] that connect to non-planar structures with virtually no energy penalty [5] suggests that phosphorene nanotubes should display a superior stability over their strained carbon counterparts [6].

Whereas individual nanotubes are straight, bundles of nanotubes are often observed as helical ropes. Natural coiling may traced back to combinations of chiral indices within the bundle [7]. Even more interesting is the possibility to twist nanotube ropes to reversibly store nanomechanical energy [8]. As a superior counterpart of twisted rubber cords, twisted nanotube ropes have the potential to store permanently and reversibly up to ten times more energy than Li-ion batteries within an unsurpassed temperature range.

Nanotube arrangement within a rope may be replicated in a complex carbon foam that could grow from carbon-saturated transition metal surfaces [9] and, while intrinsically semiconducting, displays a topologically protected conducting state at the surface [10].

The unique geometry of nanotubes inspires ideas about limitless phenomena that have not been imagined before. The enormous progress in the field is owed to scientists, who dared to try following unconventional ideas. Predictive calculations I will present offer a sound theoretical ground for imagining what has not been imagined before and for understanding, which nanotube dreams have a high potential of coming true.

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