Metamaterial built from gears

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Credit: Leiden Institute of Physics

A specifically designed collection of gears is soft on one end and rigid on the other. These robust properties hold even in the event of manufacturing imperfections. This emerging research may lead to new ways of designing geared devices like satellite trackers or watches, and

the study has been reported in *Physical Review X*.

Imagine two connected gear wheels. Turning one clockwise causes the other to turn counterclockwise. Connecting a third gear to both causes the system to get stuck. Leiden physicists Anne Meeussen and Jayson Paulose now have developed a complex assembly of gears that sticks in one place, but which operates in another. Considered as a new metamaterial, it is rigid on one end and soft on the other.

In the video below, this remarkable mechanism seems like magic, but the researchers mathematically devised it. 'The beauty of this principle is that it's a robust system,' says group leader Prof. Vincenzo Vitelli. 'We can decide which parts are soft or rigid, and the mechanism keeps working even if the gears are imperfect. This property is often called topological robustness.'

Because the rigidity properties are inherent to the system, manufacturers can use the principle to build mechanical devices like watches using cheaper components, while preserving performance. Vitelli: 'This may be best applicable to tracking devices, like satellite trackers that are based on geared mechanisms.'

The development is inspired by electronic topological insulators, which earned the 2016 Nobel Prize in Physics. They insulate on the inside, but conduct electricity on their surfaces. And even if they have imperfections, the current will keep flowing. Instead of electronic properties, Vitelli's group addresses rigidity. His systems are rigid in selected places and soft in others, irrespective of imperfections.

More information: Anne S. Meeussen et al. Geared Topological Metamaterials with Tunable Mechanical Stability, *Physical Review X* (2016). DOI: 10.1103/PhysRevX.6.041029

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