Researchers synthesize carbon nanosolenoid with Riemann surfaces

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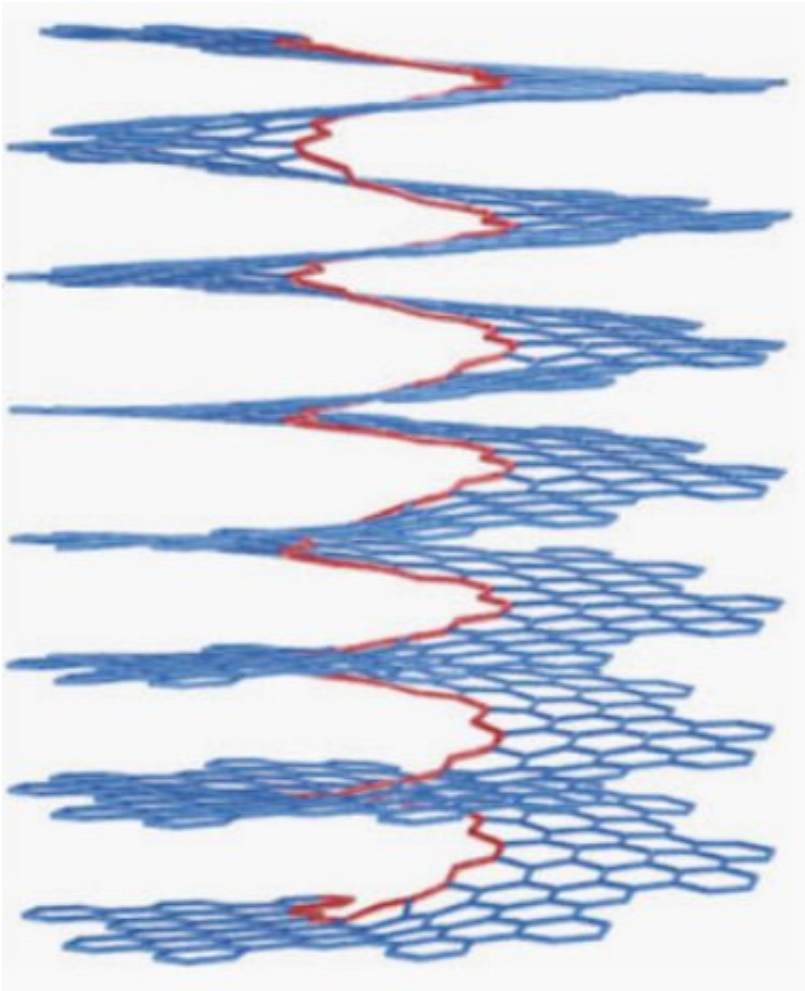

Illustration of CNS with Riemann surface. Credit: WANG Jinyi et al.

Albert Einstein constructed equations of general relativity by adopting

Riemann geometry. In addition to the key role it played in mathematics and physics, Riemann geometry has provided predictions for the properties of curved carbon materials. However, synthesis of such complicated carbon materials with Riemann surfaces remains a great challenge.

In a study published in *Nature Communications*, a research team led by Prof. Du Pingwu from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences, reported the synthesis of a π-extended nanographene carbon nanosolenoid (CNS) material. The material consisted of continuous spiral graphene planes, as was typical of Riemann surface. The CNS displayed special photoluminescence and magnetic properties.

To obtain the material, researchers first synthesized polyphenylene precursor (P1) through a Pd-mediated Suzuki coupling, then conducted a Scholl reaction as the cyclodehydrogenation step. They confirmed the existence of CNS by identifying changes in solid-state nuclear magnetic resonance (NMR) and Fourier transform infrared (FT-IR) spectrum between P1 and CNS.

Due to its extended π-conjugation, CNS exhibited red-shifted emission band compared with P1. The lifetimes of P1 and CNS also differ as measured by the time resolved photoluminescence (TRPL) technique, indicating the influence of large π-conjugation in CNS.

Conventional TEM, because of its high energy output, would cause structural damage to CNS. Thus, researchers adopted a low-dose integrated differential phase contrast scanning transmission electron microscopy (iDPC-STEM) and observed single-stranded CNS helix. The observed helical pitch and width well matched that of the calculation.

Researchers then studied the magnetic and electronic properties of CNS.

As demonstrated by electron paramagnetic resonance (EPR) spectroscopy, a large number of radicaloids existed in CNS at room temperature. Superconducting quantum interference device (SQUID) magnetometry indicated a magnetization memory effect below 150 K. Additionally, a large thermal hysteresis could be observed below 10 K as a result of breaking of π-electrons due to the helix structure.

This work introduced a facile synthetic approach of CNS with Riemann surfaces, and made it possible to study the novel physical properties of such materials.

More information: Jinyi Wang et al, Synthesis of a magnetic π-extended carbon nanosolenoid with Riemann surfaces, *Nature Communications* (2022). DOI: 10.1038/s41467-022-28870-z

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