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TOPICAL REVIEW

Microscopic investigation and manipulation of topological solitons in 1D electronic systems

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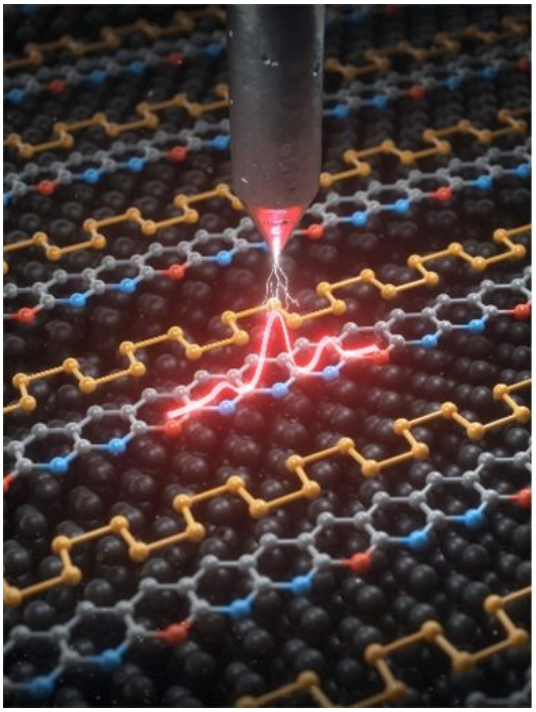
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Author introduction

Han Woong Yeom is a physicist who got his Ph.D. degree from Tohoku University and served as a professor at the University of Tokyo, Yonsei University, and, currently, POSTECH in Japan and Korea. His research focuses on the experimental investigation of the electronic properties of low-dimensional structures on solid surfaces using angle-resolved photoelectron spectroscopy and scanning tunneling spectroscopy. In particular, he has been interested in one-dimensional electronic channels on metallic monolayers and van der Waals layered materials.

Highlights

This video article reviews the recent progress in the direct microscopic observation and manipulation of individual solitons within one-dimensional electronic systems, which extends the understanding of topological solitons in electronic systems and opens up the possibility of utilizing solitons for ultra-low-energy-consumption information processing.



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Microscopic investigation and manipulation of topological solitons in 1D electronic systems

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Abstract We witness that silicon device technology, the foundation of current information civilization, is close to its end with the limit of device miniaturization and the explosive growth of energy consumption in processing information. While post-Si device architectures such as TMDC devices are under active development, technological and fundamental breakthroughs are required for devices consuming much less energy. From the physics point of view, it is a challenge to find quasi-particles and their device platforms that can carry information at higher density and without energy dissipation. While there are a few candidates such as photons, Cooper pairs, various quantum Hall currents, spin currents, and excitons, we have proposed topological solitons in 1D and 2D materials as one new direction. In 2013–2017, we made it possible to microscopically observe individual topological solitons in 1D materials for the first time since their discovery in 1979. Until 2022, we developed this research to secure model 1D systems for a few different types of microscopically accessible solitons and to track their motions. Our recent work demonstrates the manipulation of solitons and their interactions, which may open a way toward soliton technology in electronic systems. On the other hand, these works open a research field where one can study the structures, electronic states, kinetics, dynamics, and interactions of individual solitons. At the end of the video article, we show that the soliton concepts are helpful in understanding the physics of topological domain walls in complex 2D quantum materials.

Keywords atomic wires, charge densty wave, topological solitons, solitonics, scanning tunneling microscopy

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