Graphene nanoribbons: a new platform for quantum engineering

Peter H. Jacobse
University of California, Berkeley

Abstract

Graphene nanoribbons (GNRs), narrow strips of graphene, have been hailed as exciting candidates for next generation nanoelectronics. Their electronic properties are endlessly tunable by varying their width, edge structure, shape, or by incorporating heteroatoms or non-hexagonal rings. The development of new chemical bottom-up methods for their preparation (like on-surface synthesis) has enabled the preparation of numerous different types of GNRs, with atomic precision and has paved the way to exploring their intriguing properties.

Carbon is the gift that just keeps giving. We have recently prepared GNRs that could fuse laterally into a two-dimensional material (a nanoporous graphene) and made field-effect transistors (FETs) out of it. FETs can also be engineered inside GNRs by the synthesis of heterostructures. Recently, we have discovered ways to engineer (singly occupied) localized electronic states in GNRs by playing tricks with local sublattice imbalances. Emergent zero-modes can be strung together to artificially reduce the GNR band gap, induce metallicity, or to make Su-Schrieffer-Heeger type chains. I will show how low gap behavior can also be induced by putting four-membered and five-membered rings into nanoribbons. Spin-polarized zero-modes can also be coupled together through the exchange interaction, in which case GNRs exhibit pi-magnetism. I will show how we studied the coupling of zero-modes and will finally present a nanoribbon that acts as a one-dimensional Kondo lattice on a metal surface, and whose Kondo temperature can be adjusted through tip manipulation.

Bio

Peter Jacobse was born in Emmen, The Netherlands. After completing his bachelor's degree in chemistry at the University of Groningen (The Netherlands), he moved to Utrecht University (The Netherlands) to study nanomaterials science (graduated honors, *cum laude*). In Utrecht, he performed a research project on graphene nanoribbons in the group of Ingmar Swart and learned to operate a scanning tunneling/atomic force microscope. Gradually, Peter found himself falling in love with graphene nanoribbons, and his interests started to broaden from chemistry to surface science, quantum mechanics and condensed matter physics. Peter wrote a grant proposal on advancing the study of graphene nanoribbons, which was awarded by the Dutch Research Council (NWO) and resulted in him continuing his work in Ingmar's group as a PhD candidate. After receiving his PhD, Peter wrote another grant proposal about attempting to elevate the potential of graphene nanoribbons towards functional nanoelectronic components and quantum computing. This proposal was again awarded a grant by the Dutch Research Council (NWO) and secured his position as a postdoctoral researcher in the group of Michael F. Crommie at the University of California, Berkeley, where he works to this day, uncovering the deepest secrets of those tiny strips of graphene.