Carbon nanotubes as excitonic insulators

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Fifty years ago Walter Kohn speculated that a zero-gap semiconductor might be unstable against the spontaneous generation of excitons—electron-hole pairs bound together by Coulomb attraction. The reconstructed ground state would then open a gap breaking the symmetry of the underlying lattice, a genuine consequence of electronic correlations.

I will show that this ‘excitonic insulator’ is realized in zero-gap carbon nanotubes, by presenting results of first-principles calculations performed by means of many-body perturbation theory as well as quantum Monte Carlo. The excitonic order modulates the charge between the two carbon sublattices of the armchair tube, opening an experimentally observable gap which scales as the inverse of the tube radius and weakly depends on the axial magnetic field.

These findings invalidate the common wisdom that the ground state of armchair carbon nanotubes is a Luttinger liquid. I will discuss the physical origin of this conclusion, related to the strong e-h binding in quasi-1D and the almost unscreened long-range interactions in undoped nanotubes.

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