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Attraction by repulsion: pairing electrons using electrons

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One of the fundamental properties of electrons is their mutual Columbic repulsion. If electrons are placed in a solid, however, this basic property may change. A famous example is that of superconductors, where coupling to lattice vibrations makes electrons attractive and leads to the formation of bound pairs. But what if all the degrees of freedom in the solid are electronic? Is it possible to make electrons attract each other only by their repulsion to other electrons? Such an 'excitonic' mechanism for attraction was proposed fifty years ago by W. A. Little, with the hope that it could lead to better and more exotic superconductivity. Yet, despite many efforts to synthesize materials that possess this unique property, to date there is still no evidence for electronic-based attraction. In this talk I will present our recent experiments that observe this unusual electronic attraction using a different, bottom-up approach. Our experiments are based on a new generation of quantum devices made from pristine carbon nanotubes, combined with precision cryogenic manipulation. Using this setup we can now assemble the fundamental building block of the excitonic attraction and demonstrate that two electrons that naturally repel each other can be made attractive using an independent electronic system as the binding glue. I will discuss the lessons learned from these experiments on what is achievable with plain electrostatics, and on the possibility to use the observed mechanism for creating exotic states of matter.