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Wigner molecules in carbon-nanotube quantum dots MASSIMO RONTANI, ANDREA SECCHI, CNR-INFM Research Center S3, Modena, Italy — The paradigm of few-electron complexes in quantum dots (QDs) relies on the "particle-in-a-box" idea that lowest-energy orbitals are filled according to Pauli's exclusion principle. If Coulomb repulsion is sufficiently strong to overcome the kinetic energy cost of localization, a different scenario is predicted: a "Wigner" molecule (WM) forms, made of electrons frozen in space according to a geometrical pattern. Despite considerable experimental effort, evidence of the WM in semiconductor QDs has been elusive so far. Here we demonstrate theoretically that WMs occur in gate-defined QDs embedded in typical semiconducting carbon nanotubes (CNTs). Their signatures must be searched —and indeed have already been observed [Deshpande and Bockrath, Nature Phys. **4,** 314 (2008)] — in tunneling spectra. Through exact diagonalisation (ED) calculations, we unveil the inherent features of the electron molecular states. We show that, like nuclei in a usual molecule, electrons have localized wave functions and hence negligible exchange interactions. The molecular excitations are vibrations around the equilibrium positions of electrons. ED results are well reproduced by an ansatz vibrational wave function, which provides a simple theoretical model for transport experiments in ultraclean CNTs.

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