A molecular quantum ring formed from a π-conjugated macrocycle

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Quantum rings are structures that facilitate phase-coherent electron motion around a closed path and exhibit quantum phenomena, including the Aharonov-Bohm effect and persistent currents. Such ring structures may be fabricated from semiconducting materials, e.g. thermal conversion of InAs quantum dots [1], or by atomic manipulation (utilising a scanning tunnelling microscope to sequentially move individual atoms) [2]. Our approach is to utilise cyclic porphyrin polymers as molecular quantum rings. These cyclic polymers possess a delocalised π-conjugated electronic structure and have been shown to exhibit ring currents for systems containing up to 12 porphyrin sub-units (16 nm circumference) [3].

Here we present details from our recently published work [4] where the electronic structure of a molecular quantum ring (a 40 unit cyclic porphyrin polymer within stacks of 2-3 rings supported on a Ag(111) substrate) is characterised via scanning tunnelling microscopy (STM) and scanning tunnelling spectroscopy (STS). Our measurements access the energetic and spatial distribution of the electronic states and, utilising a combination of density functional theory and tight binding calculations, we interpret the experimentally obtained electronic structure in terms of coherent quantum states confined around the circumference of the π-conjugated macrocycle. These findings demonstrate that large (53 nm circumference) cyclic porphyrin polymers have the potential to act as molecular quantum rings.

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