Controlling long-distance motion of single molecules on Ag(111)

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Thermally induced diffusion of atoms and molecules on a surface is typically a random process, consisting of uncorrelated hops on the atomic surface lattice [1]. In the absence of thermal motion, a scanning tunneling microscope (STM) tip can be used to induce displacement of single molecules, typically hopping from one lattice site to the next [2]. Longer distances, beyond the manipulation pathway, have been achieved with sexiphenyl molecules on Ag(111), where the molecules were initially dragged with the STM tip over the surface and then continued to move further after the tip was retracted, albeit with deflections from their original propagation path [3]. Recently, CF_2 species were propelled up to ~5 nm on a corrugated Cu(110) surface, driven by excess energy from bond dissociation [4].

Here, we show how the motion of single di-bromo-ter-fluorene (DBTF) molecules on a Ag(111) surface can be controlled over distances of more than 100 nm with sub-picometer precision [5]. By following the tunnelling current during such an experiment, it is possible to directly measure the velocity of a single molecule. Along a given pathway of 150 nm, dislocation occurs within less than 2 ms. Thus, 75 µm/s can be determined as lower speed limit. Despite the flat fcc(111) surface, the molecules move strictly in one dimension across the surface, driven by an interplay of van der Waals and electrostatic interactions that are used to repel and attract the molecule. The large spatial extension of the motion, and its astonishing confinement allows realization of a sender-receiver experiment where a single molecule is transferred between two independent STM tips.

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