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Scanning tunneling microscopy and spectroscopy of single wall carbon nanotubes

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Carbon nanotubes (CNTs) are fascinating candidates for fundamental studies of one dimensional materials as well as for future molecular electronics applications. Their electronic structure is directly linked to their chirality which controls their semiconducting of metallic character. The link between local electronic and atomic structure is a crucial parameter which can be investigated in detail by using Scanning tunnelling microscopy (STM) and spectroscopy (STS). STS measurements are dominated by a series of Van Hove singularities (VHS) which are usually successfully described by a tight-binding model. The energy position of these singularities and the related wavefunctions which can be seen as the molecular orbitals of CNTs are two fundamental characteristics of CNTs which will be discussed in details here. The experimental visualization of the wavefunctions associated to the VHS will be presented. They exhibit a symmetry breaking in semiconducting and metallic tubes which is well described by a tight-binding model. The energy position of the VHS will then be discussed in details. The recent experimental evidence of the major role of excitons in the optical transitions in CNTs has enlightened the importance of many-body effects in the electronic structure of CNTs. In STS experiments, the electronic gaps of semiconducting tubes supported by a metallic substrate are close to the optical transitions although STS is not sensitive to the excitons and should exhibit much larger VHS separation. We will discuss this issue and show the importance of many-body effects and tube-substrate interaction in the electronic bandgaps of semiconducting tubes.