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Tools for Studying Electron and Spin Transport in Single Molecules

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Experiments in the field of single-molecule electronics are challenging in part because it can be very difficult to control and characterize the device structure. Molecules contacted by metal electrodes cannot easily be imaged by microscopy techniques. Moreover, if one attempts to characterize the device structure simply by measuring a current-voltage curve, it is easy to mistake nonlinear transport across a bare tunnel junction or a metallic short for a molecular signal. I will discuss the development of a set of experimental test structures that enable the properties of a molecular device to be tuned controllably in-situ, so that the transport mechanisms can be studied more systematically and compared with theoretical predictions. My collaborators and I are developing the means to use several different types of such experimental "knobs" in coordination: electrostatic gating to shift the energy levels in a molecule, mechanical motion to adjust the molecular configuration or the molecule-electrode coupling strength, illumination with light to promote electrons to excited states or to make and break chemical bonds, and the use of ferromagnetic electrodes to study spin-polarized transport. Our work so far has provided new insights into Kondo physics, the coupling between a molecule's electronic and mechanical degrees of freedom, and spin transport through a molecule between magnetic electrodes.

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