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**Scanning Vibronic Spectroscopy of Single Molecules**[1]

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The dynamics of a single molecule within a quantum point contact or tunnel junction can be quite complex, exhibiting motion over frequency scales ranging from kHz to THz. In this work, we examine in detail the dynamic motion of single molecules by using low-temperature scanning inelastic tunneling, isotopic sorting, and isotopic labeling. Carbon-based molecules such as carbon monoxide, $C_{60}$, and diamondoids function as prototype homonuclear and heteronuclear molecules. Target structures are assembled on surfaces via atomic manipulation or self-assembly in order to tailor local THz-scale vibrational modes and to control kHz-scale molecular motion. In addition we functionalize a scanning tunneling microscope tip and use its own THz-scale vibrational modes as a probe and a tunable perturbation. These techniques reveal structure not visible in traditional STM data. We compare this data to expected local quantum forces.

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