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Fundamental aspects of energy dissipation in friction

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Energy dissipation in friction is mediated by excitation of elementary processes including surface phonons and electronic excitations. These excitations couple through anharmonic interactions or by Frank-Condon nuclear motions to bulk substrate phonons, which ultimately appear as heat. This gives rise to numerous phenomena including friction anisotropy, velocity dependence, and dissipative surface charge motion. Friction anisotropy can appear when phonon modes with specific polarizations are forbidden in particular crystal directions. Electronic excitations have been discussed and investigated but never clearly and definitely identified as primary mechanisms in contact friction. I will discuss these topics using recent experimental results in my laboratory including the large friction anisotropy of Al-Ni-Co decagonal quasicrystals, the role of hydrogen bonding networks in determining the velocity dependence of friction and finally the control of friction by changing the carrier concentration near the surface of p and n semiconductors.