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Surprises in three-mode quantum optomechanics: adiabatic quantum state transfer and entanglement by dissipation

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The canonical quantum optomechanical system involves a single mechanical resonator interacting with photons in a single mode of a resonant cavity. Attention has recently turned to the additional rich physics possible in systems with many interacting vibrational and photonic modes. In this talk, I'll discuss theoretical work looking at the simplest step in this direction, optomechanical systems with three modes (2 photonic and one mechanical or vice-versa). With appropriate driving, the existence of a "mechanical dark mode" in such systems can allow for efficient quantum state transfer that is resilient against mechanical dissipation, similar to adiabatic population transfer schemes in atomic physics. With an alternate choice of driving, the same system can be used to generate a surprisingly large amount of entanglement. This occurs via a dissipative mechanism, where one mode in the system acts as an effective bath for the two modes that are to be entangled.