Self-energies for phonons and electrons -Dirac cone migration-

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Contributors
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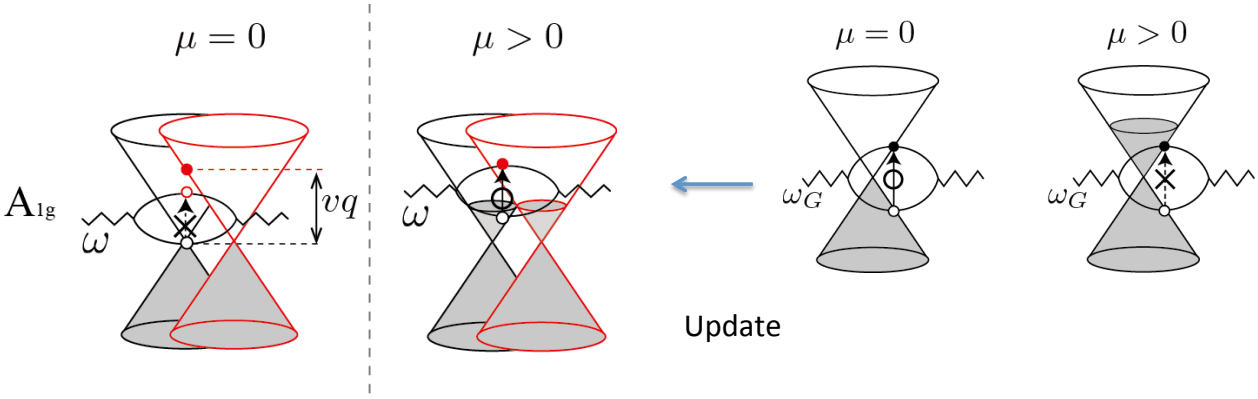
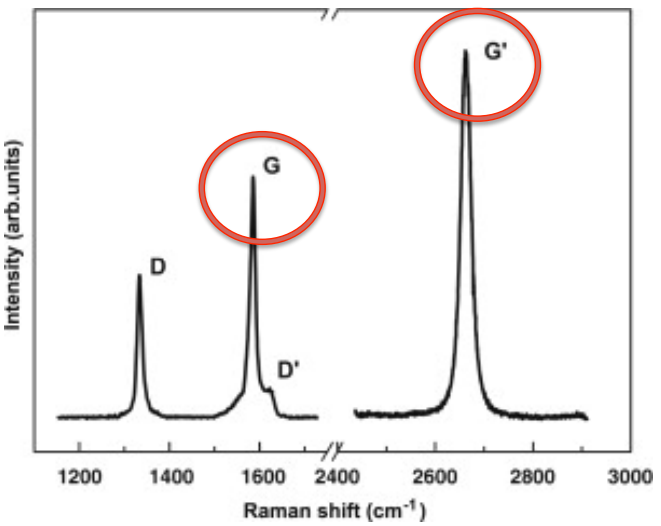
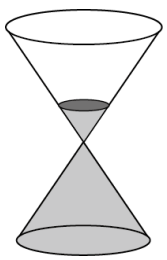
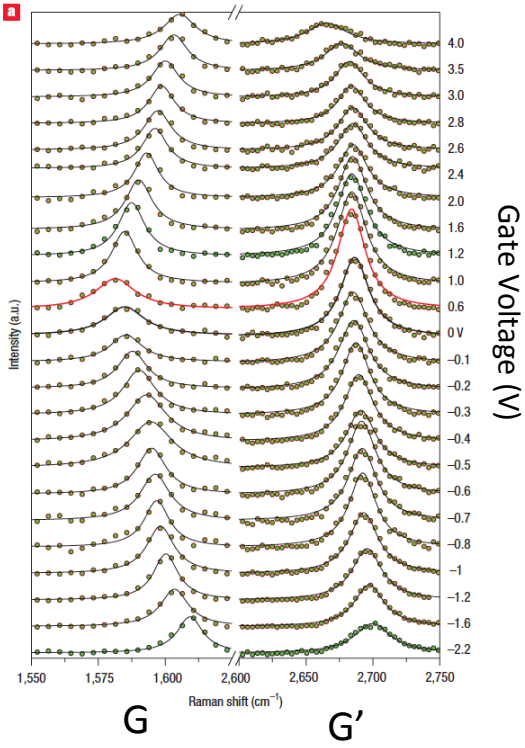


Different Doping Dependences of G and G' Bands

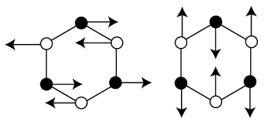






Das *et al.*, *Nature Nanotech.* **2008**

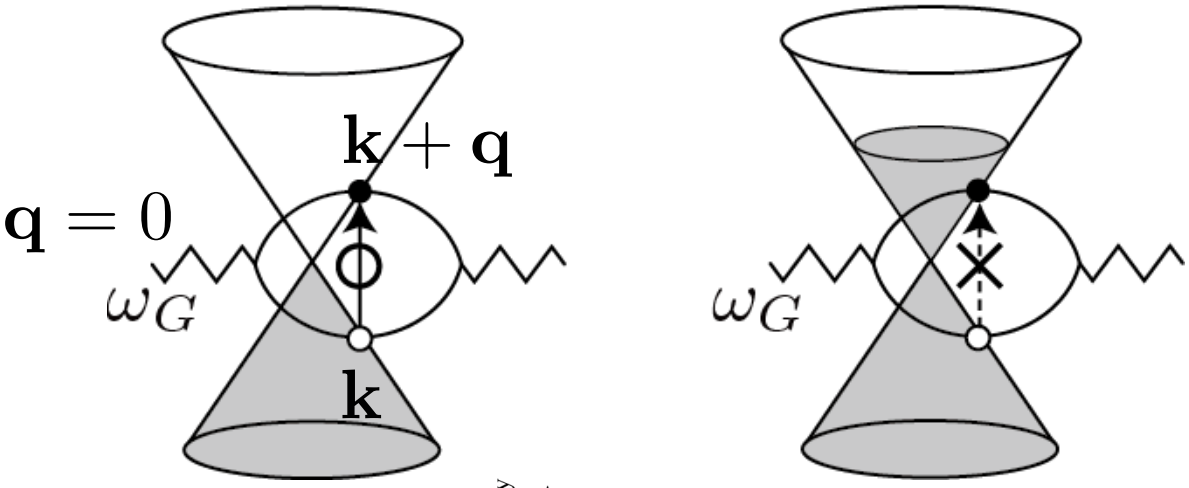
Decay of G mode (well-known)

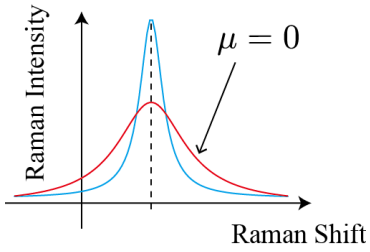


Optical

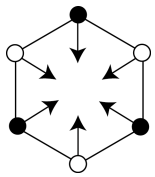
$\mathbf{q} = 0$

$\mu = 0$ $\qquad$ $\mu > 0$





Dirac Cone Migration

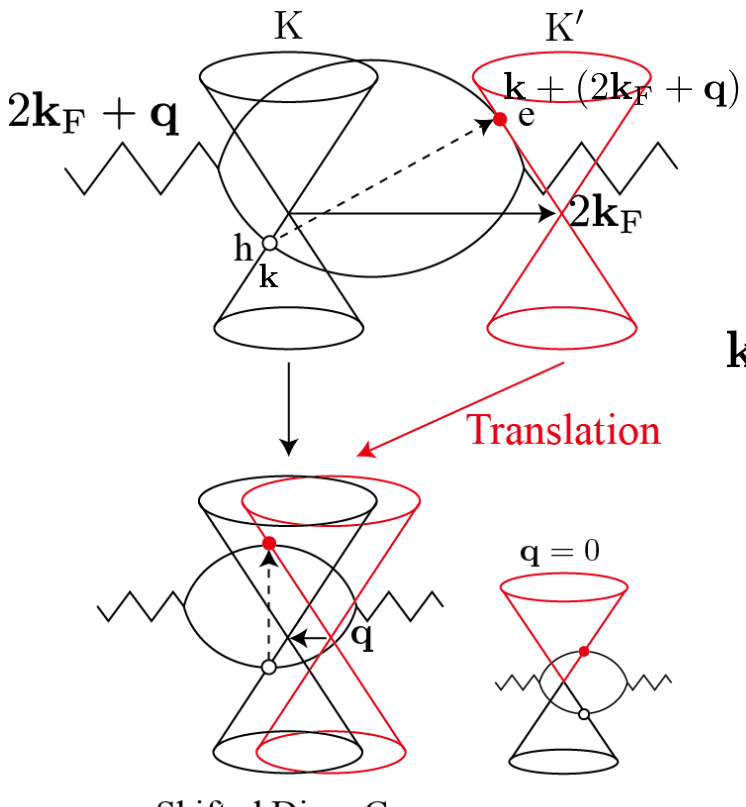


A_{1g} mode

G' = A_{1g} × 2

$\sim 2\mathbf{k}_\mathrm{F}$

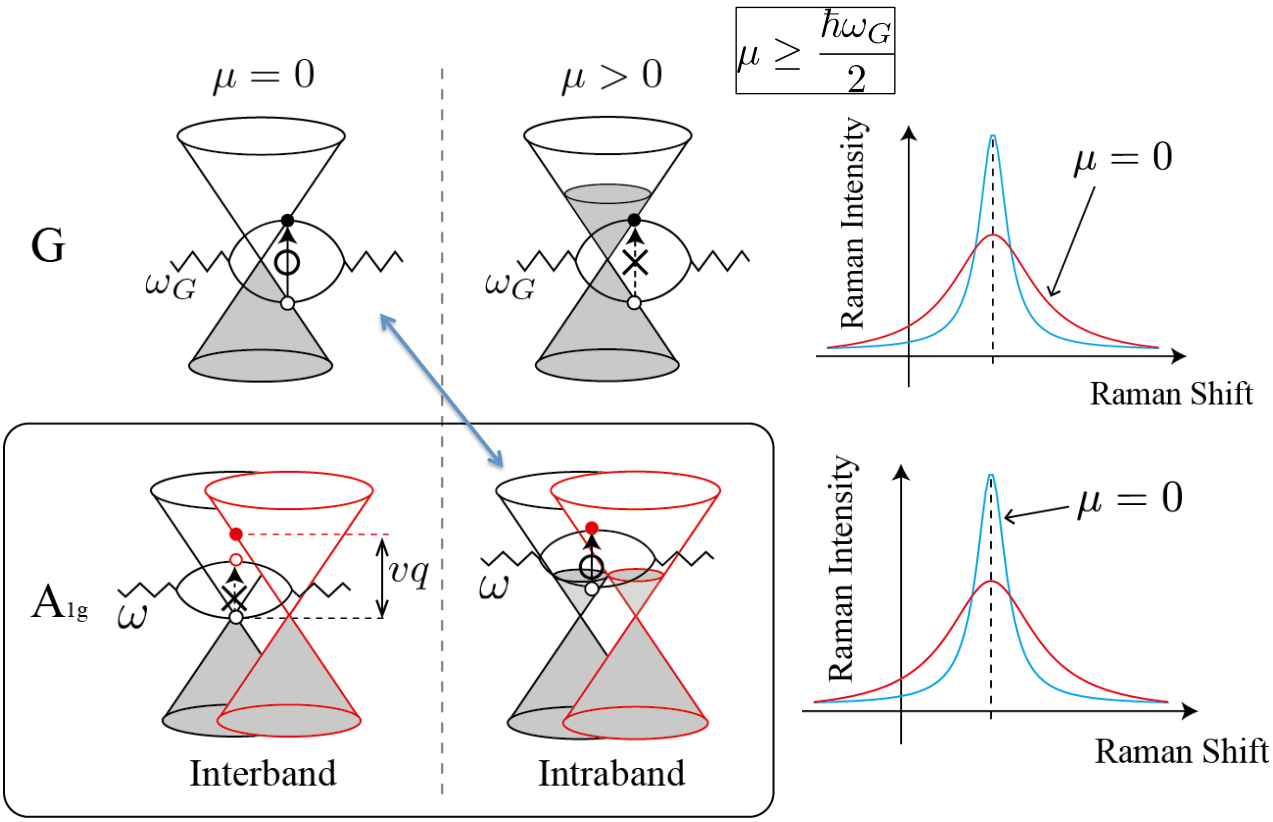
Zone boundary (intervalley phonon)



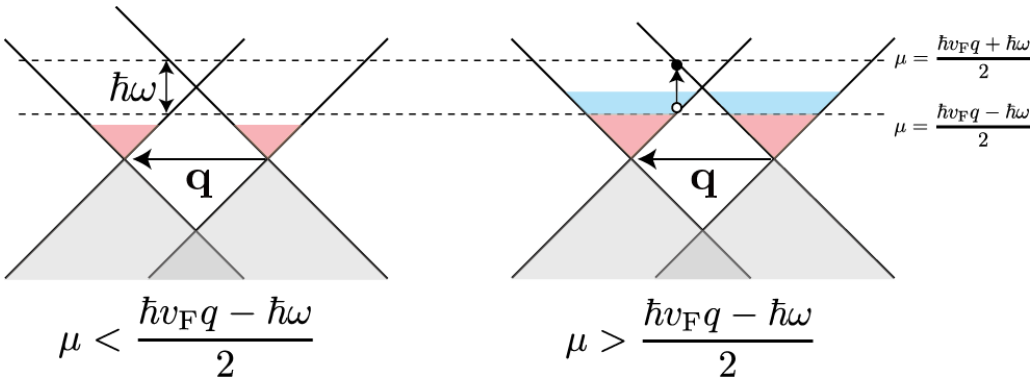
Shifted Dirac Cones

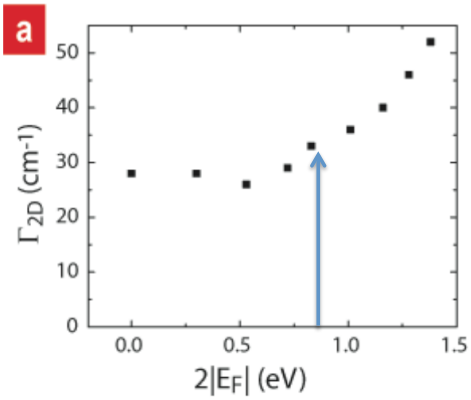
$$\mathbf{k}+(2\mathbf{k}_\mathrm{F}+\mathbf{q}) - (2\mathbf{k}_\mathrm{F}+\mathbf{q}) = \mathbf{k}$$

Different Doping dependences of G and A_{1g} modes



Determination of q-value





$\mu = 0.4$ eV

$\hbar\omega = 0.16$ eV

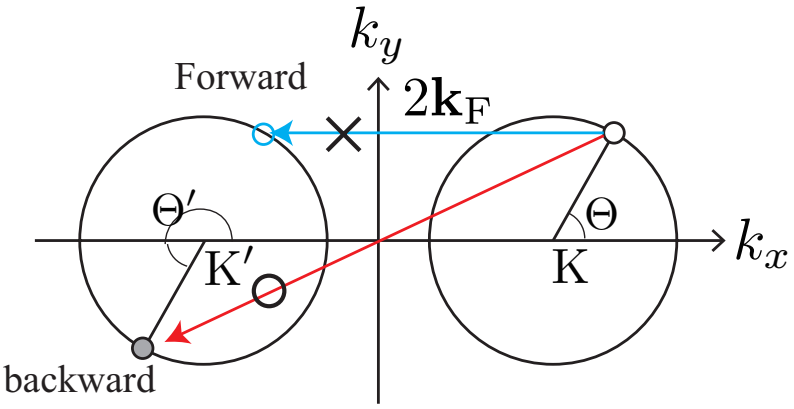
$$\mu \geq \frac{\hbar v_F q - \hbar\omega}{2}$$

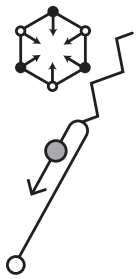
$$\hbar v_F q = 0.96 \text{ eV}$$

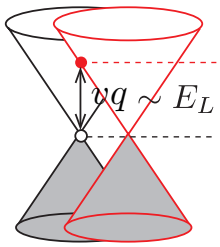
[2D means G']

Chen *et al.*, *Nature* **2011**

Dominant intervalley backward scattering





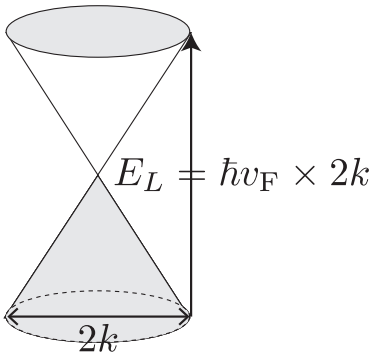


$$|M|^2 \propto 1 - \cos(\Theta' - \Theta)$$

$$2\mathbf{k}_\mathrm{F} + \mathbf{q}$$

Forward $q \sim 0$

Backward $q \sim 2k$



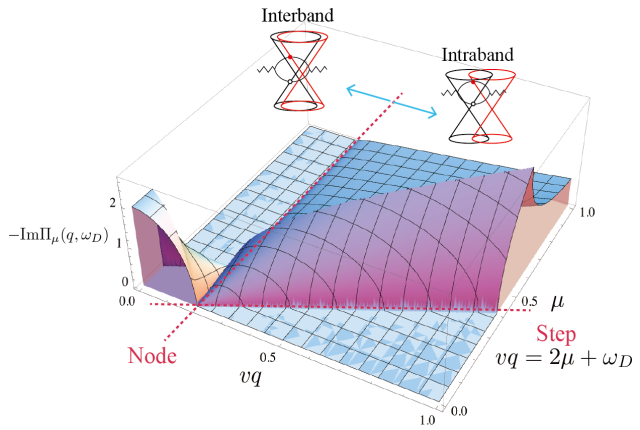
$$E_L \sim \hbar v_\mathrm{F} q$$

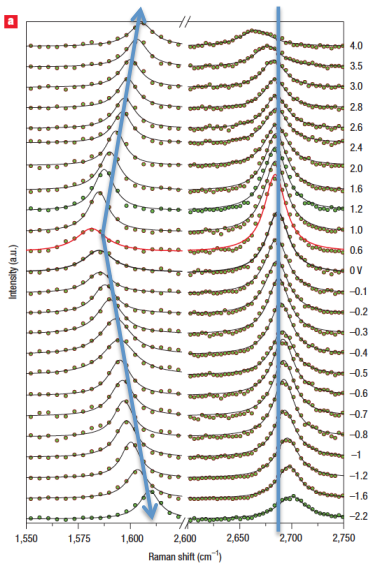
1.6eV 1eV

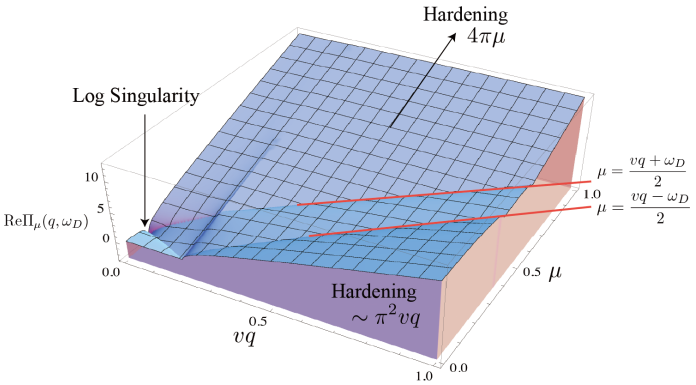
$$\langle q \rangle \sim \frac{2k}{\alpha}$$

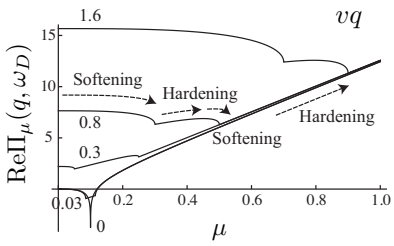
$$\alpha = 1.3$$

Self-energy of A_{1g} mode

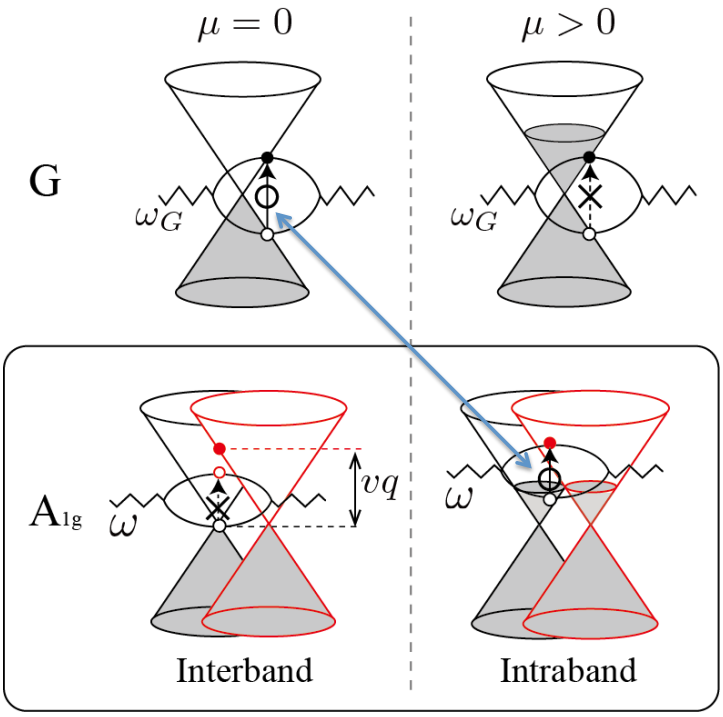


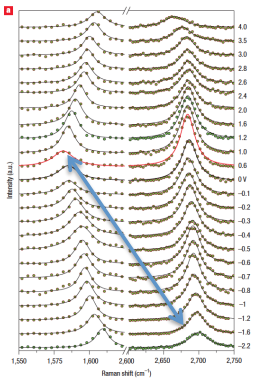


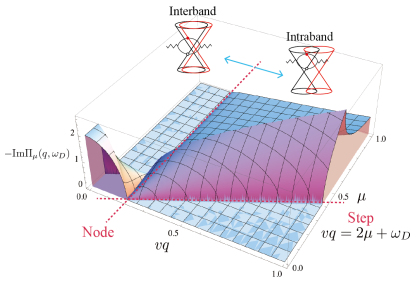


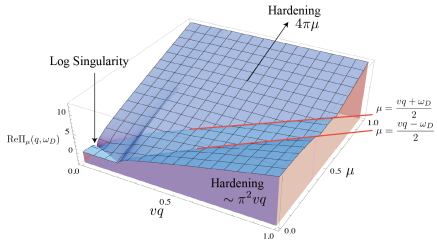


Summary



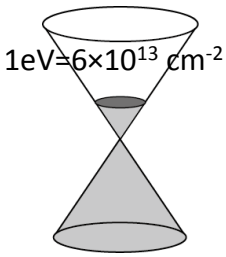


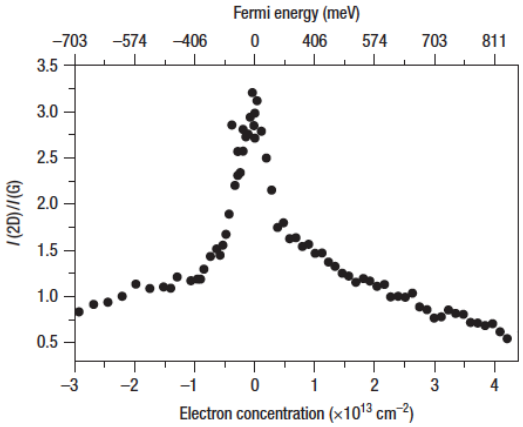




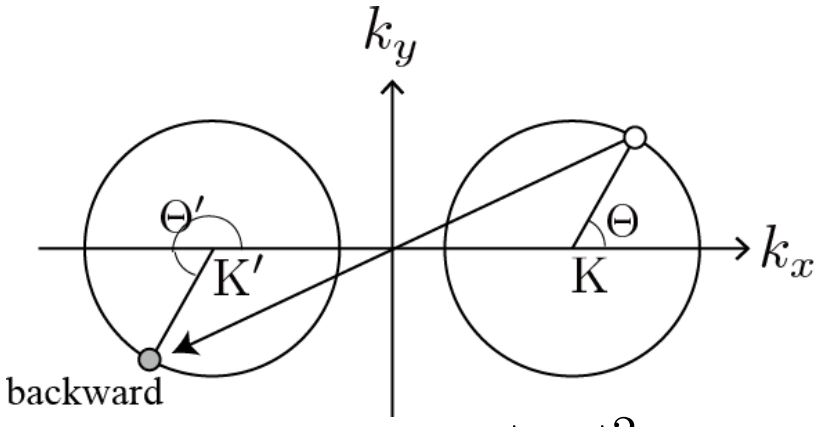
Sasaki, Kato, Tokura, Suzuki, Sogawa, arXiv:1204.4543

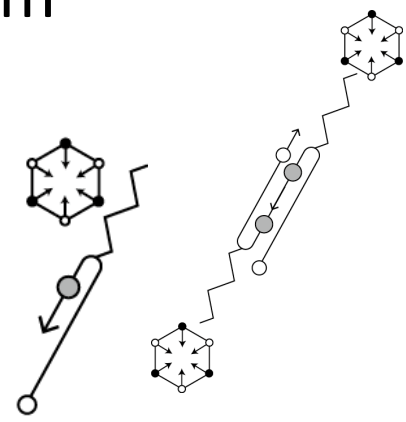
Raman 2D Band





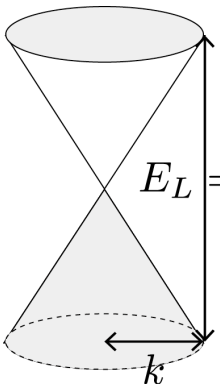
The mechanism





$$|M|^2 \propto 1 - \cos(\Theta' - \Theta)$$

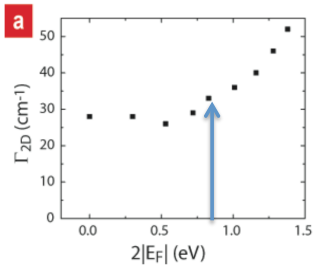
$$E_L \approx \hbar v_{\mathrm{F}} q$$



$$E_L = 2 \times \hbar v_{\mathrm{F}} k$$

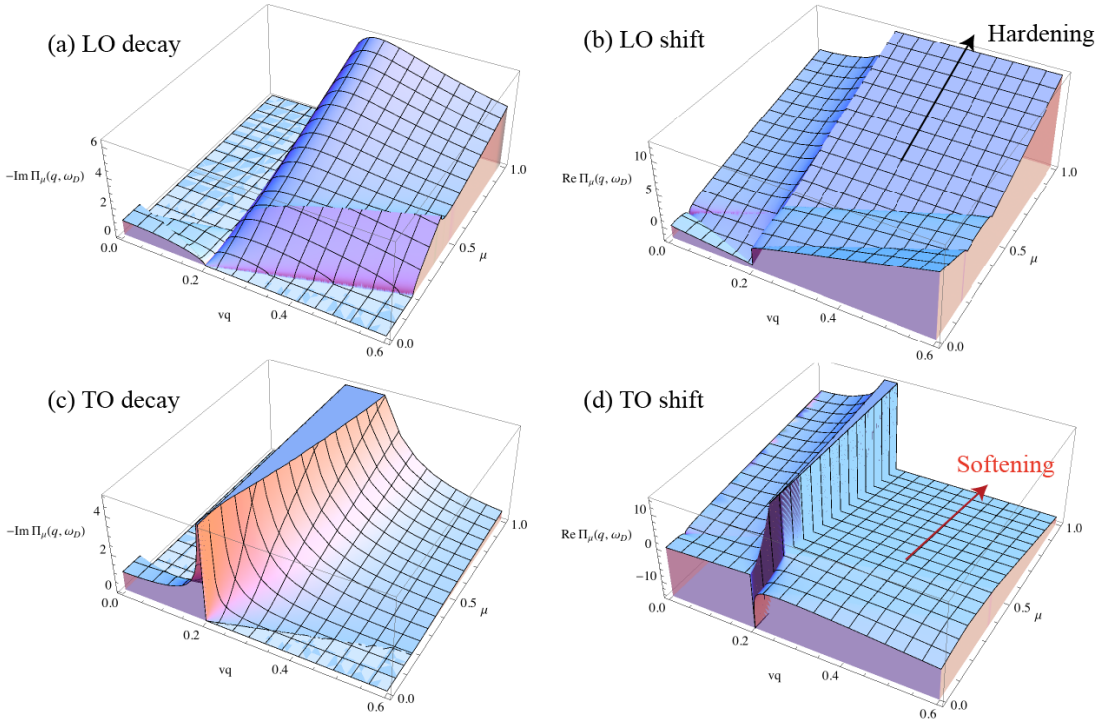
$$E_L = \alpha \times \hbar v_{\mathrm{F}} \langle q \rangle$$

1.3 (our theory)



$$\hbar v_{\mathrm{F}} q = 0.96 \text{ eV} \qquad E_L = 1.58 \text{ eV}$$

Intravalley LO and TO



Fluctuation of Fermi energy

$$p_\mu(\mu') = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(\mu'-\mu)^2}{2\sigma^2}\right) \qquad \langle \Pi_\mu(q,\omega)\rangle \equiv \int_{-\infty}^{\infty} p_\mu(\mu')\Pi_{\mu'}(q,\omega)d\mu'$$

$\sigma = 0.1$ eV