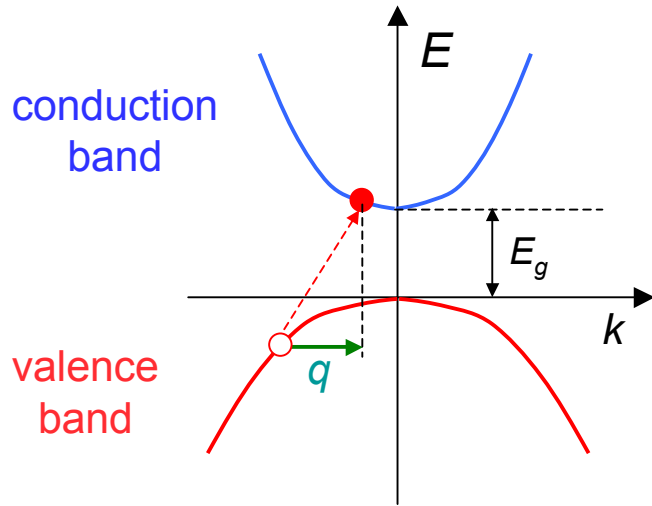
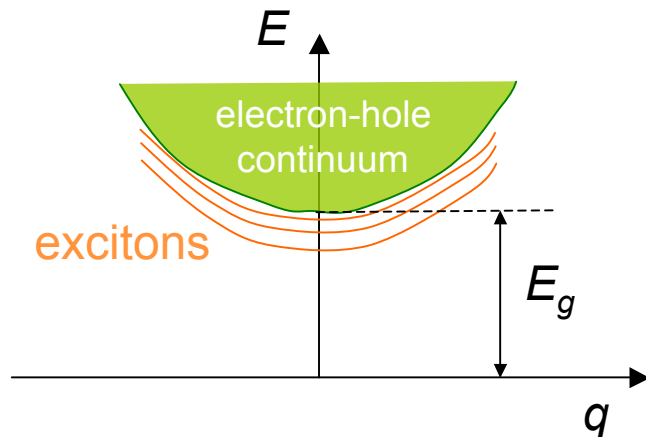


excitation spectrum of semiconductors



direct gap semiconductor



electron-hole excitation

$$|\vec{k} + \vec{q}, s; \vec{k}, s'\rangle = \hat{c}_{C, \vec{k} + \vec{q}, s}^\dagger \hat{c}_{V, \vec{k}, s'} |\Phi_0\rangle$$

excitation energy

$$E_{\vec{k}, \vec{q}} = \epsilon_{C, \vec{k} + \vec{q}} - \epsilon_{V, \vec{k}}$$

exciton: electron-hole bound state

$$E_{\vec{q}} = E_g - \frac{\mu_{\text{ex}} e^4}{2\epsilon^2 \hbar^2 n^2} + \frac{\hbar^2 \vec{q}^2}{2M_{\text{ex}}} \quad \text{"positronium"}$$

exciton
bosonic
collective mode

visible in optical
absorption spectrum

