

$$\begin{aligned} \hbar &:= 1.05459 \cdot 10^{-34} \cdot \text{J} \cdot \text{s} & q &:= 1.6 \cdot 10^{-19} \cdot \text{C} & m_0 &:= 9.11 \cdot 10^{-31} \cdot \text{kg} \\ m_e &:= 0.067 \cdot m_0 & \text{eV} &:= q \cdot \text{V} & \text{meV} &:= 10^{-3} \cdot \text{eV} \\ k_B &:= 1.38 \cdot 10^{-23} \frac{\text{J}}{\text{K}} & T &:= 300 \text{K} & k_B \cdot T &= 0.026 \cdot \text{eV} \\ \epsilon_0 &:= 8.854 \cdot 10^{-12} \frac{\text{F}}{\text{m}} & \mu_0 &:= 4\pi \cdot 10^{-7} \frac{\text{H}}{\text{m}} \end{aligned}$$

$$1 \quad a(x) := [x \cdot 5.6533 + (1 - x) \cdot 6.0584] \cdot 0.1 \text{nm}$$

$$\epsilon(x) := \frac{a(0.47) - a(x)}{a(0.47)}$$

$$E_g(x) := (0.36 + 0.505 \cdot x + 0.555 \cdot x^2) \cdot \text{eV}$$

$$a_c(x) := x \cdot (-7.17 \text{eV}) + (1 - x) \cdot (-5.08 \text{eV})$$

$$a_v(x) := x \cdot (1.16 \text{eV}) + (1 - x) \cdot (1 \text{eV})$$

$$b(x) := x \cdot (-1.7 \text{eV}) + (1 - x) \cdot (-1.8 \text{eV})$$

$$C_{11}(x) := [x \cdot 11.879 + (1 - x) \cdot 8.329] \cdot 10^{11} \frac{\text{dyne}}{\text{cm}^2}$$

$$C_{12}(x) := [x \cdot 5.376 + (1 - x) \cdot 4.526] \cdot 10^{11} \frac{\text{dyne}}{\text{cm}^2}$$

$$E_c(x) := E_g(x) + 2 \cdot a_c(x) \cdot \left(1 - \frac{C_{12}(x)}{C_{11}(x)}\right) \cdot \epsilon(x)$$

$$E_{hh}(x) := 2 \cdot a_v(x) \cdot \left(1 - \frac{C_{12}(x)}{C_{11}(x)}\right) \cdot \epsilon(x) + b(x) \cdot \left[1 + 2 \cdot \frac{C_{12}(x)}{C_{11}(x)}\right] \cdot \epsilon(x)$$

$$E_{lh}(x) := 2 \cdot a_v(x) \cdot \left(1 - \frac{C_{12}(x)}{C_{11}(x)}\right) \cdot \epsilon(x) - b(x) \cdot \left[1 + 2 \cdot \frac{C_{12}(x)}{C_{11}(x)}\right] \cdot \epsilon(x)$$

$$E_c(0.7) = 0.876 \cdot \text{eV}$$

$$E_{hh}(0.7) = -0.035 \cdot \text{eV}$$

$$E_{lh}(0.7) = 0.072 \cdot \text{eV}$$

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$$L_z := 10 \text{nm}$$

$$\gamma_1(x) := x \cdot 6.8 + (1 - x) \cdot 20.4$$

$$\gamma_2(x) := x \cdot 1.9 + (1 - x) \cdot 8.3$$

$$\gamma_3(x) := x \cdot 2.73 + (1 - x) \cdot 9.1$$

$$m_{hhz}(x) := \frac{m_0}{\gamma_1(x) - 2 \cdot \gamma_2(x)}$$

$$m_{lhz}(x) := \frac{m_0}{\gamma_1(x) + 2 \cdot \gamma_2(x)}$$

$$m_e(x) := [0.067 \cdot x + 0.023 \cdot (1 - x)] \cdot m_0$$

$$E_{e1h1}(x) := E_c(x) + \frac{\hbar^2}{2 \cdot m_e(x)} \left( \frac{\pi}{Lz} \right)^2 - \left[ E_{hh}(x) - \frac{\hbar^2}{2 \cdot m_{hhz}(x)} \left( \frac{\pi}{Lz} \right)^2 \right]$$

$$E_{e1l1}(x) := E_c(x) + \frac{\hbar^2}{2 \cdot m_e(x)} \left( \frac{\pi}{Lz} \right)^2 - \left[ E_{hh}(x) - \frac{\hbar^2}{2 \cdot m_{lhz}(x)} \left( \frac{\pi}{Lz} \right)^2 \right]$$

$$E_{e1h1}(0.7) = 0.993 \cdot eV$$

$$E_{e1l1}(0.7) = 1.051 \cdot eV$$

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$$m_{hht}(x) := \frac{m_0}{\gamma_1(x) + \gamma_2(x)} \quad \frac{m_{hht}(0.7)}{m_0} = 0.068 \quad \frac{m_e(0.7)}{m_0} = 0.054$$

$$m_{lht}(x) := \frac{m_0}{\gamma_1(x) - \gamma_2(x)} \quad \frac{m_{lht}(0.7)}{m_0} = 0.142$$

$$m_{r_{hh}}(x) := \left( m_e(x)^{-1} + m_{hht}(x)^{-1} \right)^{-1} \quad \frac{m_{r_{hh}}(0.7)}{m_0} = 0.03$$

$$m_{r_{lh}}(x) := \left( m_e(x)^{-1} + m_{lht}(x)^{-1} \right)^{-1} \quad \frac{m_{r_{lh}}(0.7)}{m_0} = 0.039$$

Peak optical gain is proportional to the joint optical density of states, which is proportional to the reduced effective mass in the quantum well:

$$hh\_lh\_Gain\_ratio := \frac{m_{r_{hh}}(0.7)}{m_{r_{lh}}(0.7)} \quad hh\_lh\_Gain\_ratio = 0.77$$