0.1 Dressed atom model

$$|\mathrm{I},n\rangle = -sin\theta\,|1,n+1\rangle + cos\theta\,|2,n\rangle$$

$$|\mathrm{II},n\rangle = cos\theta\,|1,n+1\rangle + sin\theta\,|2,n\rangle$$

$$cos\theta = \frac{\Omega_n - \delta}{\sqrt{(\Omega_n - \delta)^2 + 4g^2(n+1)}}$$

$$sin\theta = \frac{2g\sqrt{n+1}}{\sqrt{(\Omega_n - \delta)^2 + 4g^2(n+1)}}$$

$$H = H_0 + H'$$

$$H_0 = H_0^{atom} + H_0^{field} = \frac{1}{2}\hbar\omega_0\sigma_z + \hbar\omega(a^\dagger a_{\frac{1}{2}})$$

$$H' = \hbar(g_{12}a^\dagger\sigma_- + g_{21}a\sigma_+)$$

0.2 Expressions for the New Eigen states

$$\hat{H}_{xp} = \hat{H}_P + \hat{H}_x + \hat{H}_i$$

$$\hat{H}_p = E_c\hat{f}^\dagger\hat{f}$$

$$\hat{H}_x = E_x\hat{e}^\dagger\hat{e}$$

$$\hat{H}_i = \hbar\Omega(\hat{f}^\dagger\hat{e} + \hat{f}\hat{e}^\dagger)$$

$$M = |\langle\phi_X|d\cdot E|\phi_C|$$

$$\omega_R = \frac{e|E_0|M}{m\hbar\omega_0}$$

$$f^{(3D)} = \frac{2m_rE_{res}}{\hbar^2}M^2\frac{V}{\pi a_B^3}$$

$$f^{(2D)} = N_{QW}\frac{8f^{(3D)}}{\pi a_{B(3D)}^2}$$

$$g \propto \sqrt{\frac{f^{(2D)}}{m_e n_{eff}^2 L_{eff}}} \propto \sqrt{N_{QW}}$$

$$\hat{l}_{k_\parallel} = X_{k_\parallel}\hat{e}_{k_\parallel} + C_k\hat{f}_{k_\parallel}$$

$$\hat{u}_{k_\parallel} = -C_{k_\parallel}\hat{e}_{k_\parallel} + X_{k_\parallel}\hat{f}_{k_\parallel}$$

$$\hat{H}_{xp} = \Sigma_{N,k_\parallel}E_{LP}(k_\parallel)\hat{l}_{k_\parallel}^\dagger\hat{l}_{k_\parallel} + \Sigma_{N,k_\parallel}E_{UP}(k_\parallel)\hat{u}_{k_\parallel}^\dagger\hat{u}_{k\parallel}$$

$$\hat{H}_{xp}\,|\Psi\rangle = \begin{pmatrix} E_c & \hbar\Omega \\ \hbar\Omega & E_X \end{pmatrix}\begin{pmatrix} C \\ X \end{pmatrix} = E_{XP}\,|\Psi\rangle$$

$$|C_{k_\parallel}|^2 + |X_{k_\parallel}|^2 = 1$$

$$|C_{k_\parallel}|^2 = \frac{1}{2}(1 - \frac{\Delta k_\parallel}{(\Delta k_\parallel)^2 + (2\hbar\Omega)^2})$$

$$|X_{k_\parallel}|^2 = \frac{1}{2}(1 + \frac{\Delta k_\parallel}{(\Delta k_\parallel)^2 + (2\hbar\Omega)^2})$$

$$\Delta k_\parallel = E_c(k_\parallel) - E_x(k_\parallel)$$

$$E_{LP,UP}(k_\parallel) = \frac{1}{2}[E_C(k_\parallel) + E_X(k_\parallel) \pm \sqrt{(2\hbar\Omega)^2 + (\Delta(k_\parallel))^2}]$$

0.3 equations for presentation

$$ABX_3$$

$$(LA)_2(A)_{n-1}B_nX_{3n-1}$$

$$0.9 < t < 1$$

$$0.8 < t < 0.9$$

$$Cs^+$$

$$MA^+$$

$$FA^+$$

$$CsPbBr_3$$

$$Cs_4PbBr_6$$

$$MAPBI_3$$