Interaction of N-level atoms with photon states in cavities

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Abstract

The dynamics of the interaction of two multilevel atoms with photon modes in cavities is studied numerically. The equations of motion of the system were derived using the methods of coherent states of photons and atoms and the corresponding groups of their dynamical symmetries. The different arrangement of atoms, their movement in the cavity, and the entanglement of their initial states were also taken into account. Photon losses were taken into account in the Wigner-Weisskopf approximation..

N-level atoms in cavity fields (N=3)

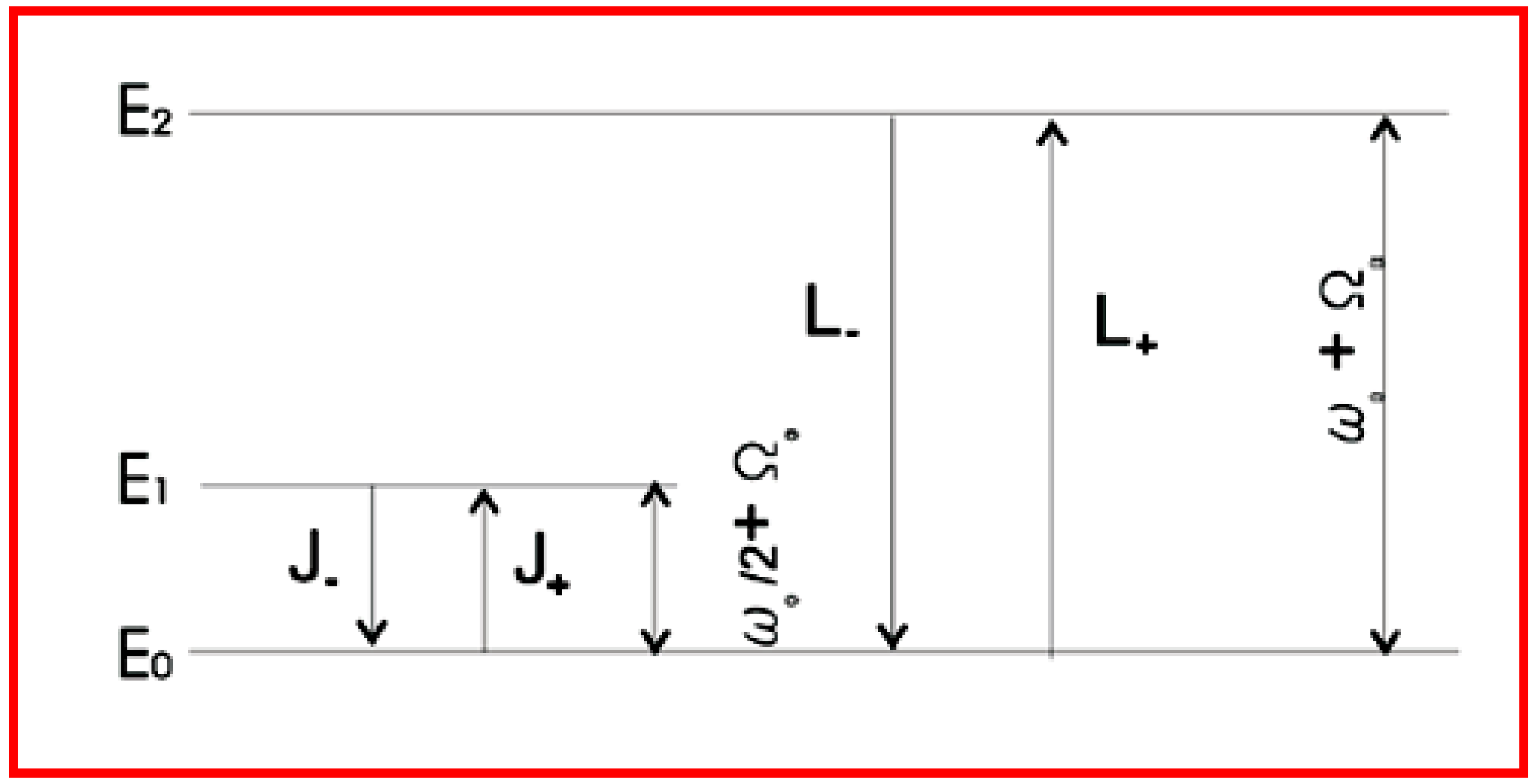
$$\hat{H}(t)=\omega_0(\hat{H}_1^{(1)}+\hat{H}_1^{(2)})++\Omega_0(\hat{H}_2^{(1)}+\hat{H}_2^{(2)})+\omega_1\hat{a}_1^+\hat{a}_1+\omega_2\hat{a}_2^+\hat{a}_2+$$
$$+\left\{g_1^{(1)}(t)\left(\hat{J}_+^{(1)}+\hat{J}_-^{(1)}\right)+g_1^{(2)}(t)\left(\hat{J}_+^{(2)}+\hat{J}_-^{(2)}\right)\right\}(\hat{a}_1^++\hat{a}_1)+$$
$$+\left\{g_2^{(1)}(t)\left(\hat{L}_+^{(1)}+\hat{L}_-^{(1)}\right)+g_2^{(2)}(t)\left(\hat{L}_+^{(2)}+\hat{L}_-^{(2)}\right)\right\}(\hat{a}_2^++\hat{a}_2).$$

$$g_1^{(1)}(t)=g_1\cdot\left[\theta(t)-\theta(t-l/v_1)\right]\cdot\sin\left(\frac{\pi v_1}{l}t\right),\; g_1^{(2)}(t)=g_1\cdot\left[\theta(t-t_2^0)-\theta(t-t_2^0-l/v_2)\right]\cdot\sin\left(\frac{\pi v_2}{l}t\right),$$

$$g_2^{(1)}(t)=g_2\cdot\left[\theta(t)-\theta(t-l/v_1)\right]\cdot\sin\left(\frac{\pi v_2}{l}t\right),\; g_2^{(2)}(t)=g_2\cdot\left[\theta(t-t_2^0)-\theta(t-t_2^0-l/v_2)\right]\cdot\sin\left(\frac{\pi v_2}{l}t\right).$$

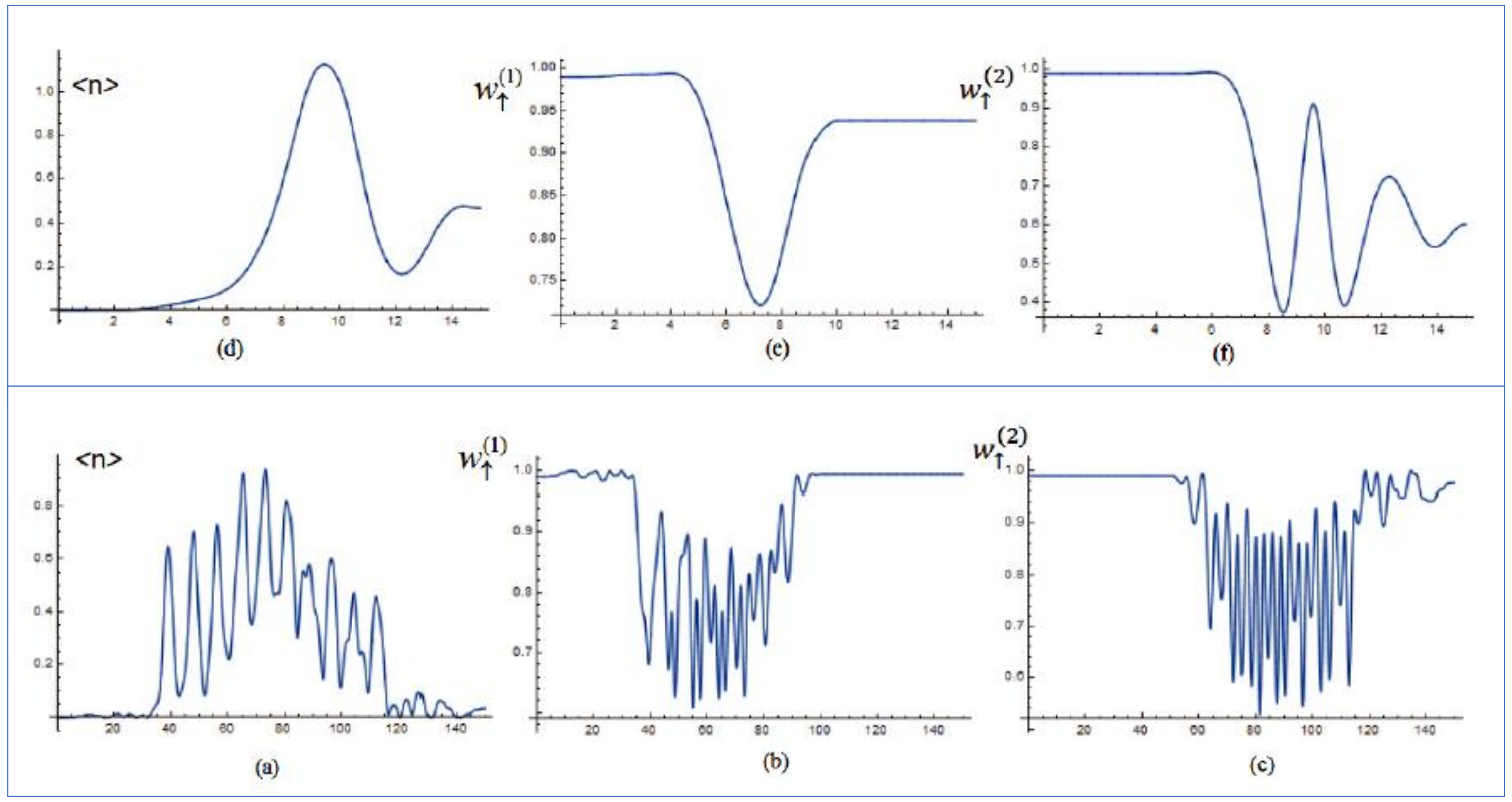
$$\left|Z\right\rangle=\left|\alpha_1,\alpha_2\right\rangle\times\left|z_1^{(1)},z_2^{(1)}\right\rangle\times\left|z_1^{(2)},z_2^{(2)}\right\rangle,\; G=W_2\times SU(3)\times SU(3)$$

$$\begin{cases}
i\dot{\alpha}_1=\omega_1\alpha_1+g_1^{(1)}(t)\dfrac{z_1^{(1)}+\bar{z}_1^{(1)}}{1+z_1^{(1)}\bar{z}_1^{(1)}+z_2^{(1)}\bar{z}_2^{(1)}}+g_1^{(2)}(t)\dfrac{z_1^{(2)}+\bar{z}_1^{(2)}}{1+z_1^{(2)}\bar{z}_1^{(2)}+z_2^{(2)}\bar{z}_2^{(2)}},\\
i\dot{\alpha}_2=\omega_1\alpha_2+g_2^{(1)}(t)\dfrac{z_2^{(1)}+\bar{z}_2^{(1)}}{1+z_1^{(1)}\bar{z}_1^{(1)}+z_2^{(1)}\bar{z}_2^{(1)}}+g_2^{(2)}(t)\dfrac{z_2^{(2)}+\bar{z}_2^{(2)}}{1+z_1^{(2)}\bar{z}_1^{(2)}+z_2^{(2)}\bar{z}_2^{(2)}},\\
i\dot{z}_1^{(1)}=\Omega_1^{(1)}z_1^{(1)}-g_1^{(1)}(t)(\alpha_1+\bar{\alpha}_1)z_1^{(1)}z_2^{(1)}+g_2^{(1)}(t)(\alpha_2+\bar{\alpha}_2)\left(z_1^{(1)}z_1^{(1)}-1\right),\\
i\dot{z}_2^{(1)}=\Omega_2^{(1)}z_2^{(1)}-g_2^{(1)}(t)(\alpha_2+\bar{\alpha}_2)z_1^{(1)}z_2^{(1)}+g_1^{(1)}(t)(\alpha_1+\bar{\alpha}_1)\left(z_2^{(1)}z_2^{(1)}-1\right),\\
i\dot{z}_1^{(2)}=\Omega_1^{(2)}z_1^{(2)}-g_1^{(2)}(t)(\alpha_1+\bar{\alpha}_1)z_1^{(2)}z_2^{(2)}+g_2^{(2)}(t)(\alpha_2+\bar{\alpha}_2)\left(z_1^{(2)}z_1^{(2)}-1\right),\\
i\dot{z}_2^{(2)}=\Omega_2^{(2)}z_2^{(2)}-g_2^{(1)}(t)(\alpha_2+\bar{\alpha}_2)z_1^{(1)}z_2^{(2)}+g_1^{(2)}(t)(\alpha_1+\bar{\alpha}_1)\left(z_1^{(2)}z_2^{(2)}-1\right).
\end{cases}$$



V-atom. Energy levels and transitions

Numerical calculations



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