Modification of transmission gaps by an optical field in a molecular field-effect transistor

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The Hamiltonian of 1M2-system

$$H = H_e + H_m + H_{int} + H_f(t)$$

$$H_e = \sum_{r\mathbf{k}\sigma} E_{r\mathbf{k}} a^+_{r\mathbf{k}\sigma} a_{r\mathbf{k}\sigma} \quad - \text{ electrode's Hamiltonain}$$

$$H_m = \sum_{M(N)} E_{M(N)} \left| M(N) \right\rangle \left\langle M(N) \right| \quad - \text{ molecular Hamiltonian}$$

$$H_{int} = \sum_{r\mathbf{k}\sigma} \sum_{N,MM'} \left[V_{M'(N+1);r\mathbf{k}\sigma M(N)} \times \left| M'(N+1) \right\rangle \left\langle M(N) a_{r\mathbf{k}\sigma} \right| + h.c. \right]$$
$$- \text{ Hamiltonian of interaction between electrodes and molecule}$$

$$H_f(t) = -\mathbf{E}(t) \sum_{MM'N} \mathbf{d}_{M'M} \left| M'(N) \right\rangle \left\langle M(N) \right|$$
$$- \text{ Hamiltonian of interaction with electromagnetic field}$$

$$\mu_r = E_F - |e| V \delta_{r,R}, \quad V > 0$$