CONSERVATION OF MOMENTUM LAW A QUASIPARTICLE

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Abstract: In this paper, we obtain a function that implements the representation of a translation group and corresponds to the components of a system with a certain total momentum P and whose wave function satisfies the Schrodinger equation with the Hamiltonian and describes the fulfillment of the law of conservation of momentum.

Key words: The law of conservation of momentum, quasi-particle, the Hamiltonian, the effective mass operator of the phonon.

Within the frame work of the effective mass method in the one-electron approximation, we write the Hamiltonian of the electron-phonon system in the following form:

$$H = \frac{1}{2m^*} p_r^2 + \gamma \sum_f \left(v_f^{(0)} e^{ifr} b_f + v_f^{(0)*} e^{-ifr} b_f^+ \right) + \frac{1}{2} \sum_f \hbar \omega_f (b_f^+ b_f + b_f b_f^+) \quad (1)$$

$$\gamma = \alpha_c^{1/2}, \quad \alpha_c = \frac{1}{2} \left(\frac{1}{\epsilon_\infty} - \frac{1}{\epsilon_s} \right) \frac{e^2 u}{\hbar \omega_f}$$

where

m^* - isotropic effective mass of the electron at the bottom of the conduction band; ω_f - frequency of optical vibrations visual environment; ϵ_∞ and ϵ_s - the high-frequency and low-frequency dielectric permittivity's of an isotropic ally polarizing; r - the electron coordinate.

To construct a series of perturbation theory, let us pass in the Hamiltonian (1) from the phonon generation and annihilation operators to the complex coordinates of the phonon field q_f and its conjugate momentum operators p_f according to the

$$\text{relations: } q_f = \frac{1}{\gamma} \frac{b_f + b_{-f}^+}{\sqrt{2}}, \quad p_f = i\gamma \frac{b_f^+ + b_{-f}}{\sqrt{2}} \quad (2)$$

Given formula (2) and operator: $\partial/\partial r = (\partial\lambda/\partial r)\partial/\partial\lambda = \gamma\partial/\partial\lambda$, we transform the Hamiltonian (1) to the following form:

$$H = \frac{\gamma^2}{2m^*} p_\lambda^2 + \sqrt{2}\gamma^2 \sum_f v_f^{(0)} q_f e^{if(q+\lambda/\gamma)} + \\ + \frac{\gamma^2}{2} \sum_f \hbar\omega_f q_{-f} q_f + \frac{1}{2\gamma^2} \sum_f \hbar\omega_f p_{-f} p_f \quad (3)$$

The system pulse indicator can be written as:

$$-i\hbar \frac{\partial}{\partial q} = -i\hbar \frac{\partial}{\partial r} - i\hbar \sum_f f q_f p_f \quad (4)$$

We define the momentum operator p_f in terms of new variables q, λ and Q_f :

$$p_f = -i \frac{\partial}{\partial q_f} = \\ = i \sum_k \frac{\partial Q_k}{\partial q_f} \frac{\partial}{\partial Q_k} - i \frac{\partial q}{\partial q_f} \frac{\partial}{\partial q} - i \frac{\partial \lambda}{\partial q_f} \frac{\partial}{\partial \lambda} - \\ \frac{\partial q}{\partial q_k} = ikv_k^* e^{ikq} - \frac{1}{\gamma} \sum_f (ff) v_f^* Q_f \frac{\partial q}{\partial q_k} \quad (5)$$

Expression (5) has series expansions in the form:

$$\frac{\partial q}{\partial q_k} = ie^{ikq} \left[kv_k^* - \frac{1}{\gamma} \sum_f f(fk) v_k^* v_f^* Q_f + \right. \\ \left. + \frac{1}{\gamma^2} \sum_{f,1} k(fI)(fI) v_k^* v_f^* v_I^* Q_f Q_I + \dots \right] \quad (6)$$

Applying standard methods of perturbation theory we have:

$$H = \frac{\gamma^2}{2m^*} p_\lambda^2 + \sqrt{2}\gamma^2 \sum_f v_f^{(0)} u_f e^{if\lambda/\gamma} + \\ + \gamma^2 \sum_f \frac{\hbar}{2} \omega_f u_f u_{-f} + \gamma \sum_f \left[\sqrt{2} V_f^{(0)} Q_f e^{if\lambda/\gamma} + \right. \\ \left. + \frac{\hbar}{2} \omega_f (u_{-f} Q_f + u_f Q_{-f}) \right] + \sum_f \frac{\hbar}{2} \omega_f Q_{-f} Q_f + \\ + \frac{1}{2\gamma^2} \sum_f \hbar \omega_f p_{-f} p_f = -\frac{\gamma^2 \gamma^2}{2m^*} \frac{\partial^2}{\partial \lambda^2} + \\ + \sqrt{2}\gamma^2 \sum_f v_f^{(0)} \left(u_f + \frac{1}{\gamma} Q_{-f} \right) e^{if\lambda/\gamma} + \\ + \frac{1}{2}\gamma^2 \sum_f \hbar \omega_f \left(u_f^* + \frac{1}{\gamma} Q_{-f} \right) \left(u_f + \frac{1}{\gamma} Q_f \right) - \\ - \frac{1}{2\gamma^2} \sum_f \hbar \omega_f \left(\gamma^2 \left[\frac{\partial}{\partial Q_{-f}} - \right. \right. \\ \left. \left. - i v_f^{(*)} \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) \right] \frac{\partial}{\partial Q_f} + \right. \\ \left. + i f v_f^{(*)} \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) \right] + \\ + \gamma \left\{ \left[- \sum_k (fk) v_{-f}^* Q_k \frac{\partial}{\partial Q_k} + \right. \right.$$

$$\begin{aligned}
 & + \sum_k k(fk) v_{-f}^* v_k^* Q_k \left(i \sum_I I u_I \frac{\partial}{\partial Q_I} - \frac{\partial}{\partial \lambda} \right) - f v_{-f}^* + \frac{\partial}{\partial q} \Bigg] \times \\
 & \times \left[\frac{\partial}{\partial Q_f} + i f v_f^* \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) \right] + \\
 & + \left[\frac{\partial}{\partial Q_{-f}} - i f v_{-f}^* \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) \right] + \\
 & + \left[\frac{\partial}{\partial Q_{-f}} - i f v_{-f}^* \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) \right] \times \\
 & \times \left[\sum_k (fk) v_f^* Q_k \frac{\partial}{\partial Q_k} \right. \\
 & \left. - \sum_k k(fk) v_f^* v_k^* Q_k \left(i \sum_I I u_I \frac{\partial}{\partial Q_I} - \frac{\partial}{\partial \lambda} \right) + f v_f^* \frac{\partial}{\partial q} \right] \Bigg\} + \\
 & + \left\{ - \sum_{k,I} f(kI) (kI) v_{-f}^* v_k^* v_I^* Q_k Q_I \left(i \sum_I I u_I \frac{\partial}{\partial Q_I} - \frac{\partial}{\partial \lambda} \right) + \right. \\
 & + \sum_k k(kf) v_{-f}^* v_k^* Q_k \sum_I I Q_I \frac{\partial}{\partial Q_I} + \\
 & + \sum_k k(fk) v_{-f}^* v_k^* Q_k \frac{\partial}{\partial Q_I} \left[\frac{\partial}{\partial Q_f} + \right. \\
 & + i f v_f^* \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) + \\
 & + \left[\sum_k (fk) v_{-f}^* Q_k \frac{\partial}{\partial Q_k} + \right. \\
 & + \sum_k k(fk) v_{-f}^* v_k^* Q_k \left(i \sum_I I u_I \frac{\partial}{\partial Q_I} - \frac{\partial}{\partial \lambda} \right) - f v_{-f}^* \frac{\partial}{\partial q} \Bigg] \times \\
 & + \left[\sum_k (fk) v_f^* Q_k \frac{\partial}{\partial Q_k} - \right.
 \end{aligned}$$

$$\begin{aligned}
 & - \sum_k k(fk) v_f^* v_k^* Q_k \left(i \sum_I I u_I \frac{\partial}{\partial Q_I} - \frac{\partial}{\partial \lambda} \right) + f v_f^* \frac{\partial}{\partial q} \Bigg] + \\
 & + \left[\frac{\partial}{\partial Q_f} - i f v_{-f}^* \left(i \sum_k k u_k \frac{\partial}{\partial Q_k} - \frac{\partial}{\partial \lambda} \right) \right] \times \\
 & \times \left[\sum_{k,I} f(kI) (kI) v_f^* v_k^* v_I^* Q_k Q_I \left(i \sum_I I u_I \frac{\partial}{\partial Q_I} - \frac{\partial}{\partial \lambda} \right) - \right. \\
 & - \sum_k k(kf) v_f^* v_k^* Q_k \sum_I I Q_I \frac{\partial}{\partial Q_I} - \\
 & \left. - \sum_k k(kI) v_f^* v_k^* Q_k \frac{\partial}{\partial q} \right] \Bigg\} + \dots
 \end{aligned} \tag{7}$$

Then the total eigen function of the system has the following form системы имеет следующий вид:

$$\Psi(\lambda, q, Q_f) = \exp\left(\frac{i}{\hbar} \gamma^2 I q\right) \Phi(\lambda, Q_f) \tag{8}$$

This function implements the representation of the translation group and corresponds to the components of the system with a certain total momentum P and the wave function satisfies the Schrodinger equation with the Hamiltonian (7) and describes the evolution of the system taking into account the law of conservation of pulse.

Thus, transforming the wave function with respect to the variable Q_f , we have:

$$\begin{aligned}
 \Psi(\lambda, q, Q_f) &= \exp\left(i \gamma \sum_f s_f Q_f\right) \times \\
 &\times \exp\left(\frac{i}{\hbar} \gamma^2 I q\right) \Phi(\lambda, Q_f)
 \end{aligned} \tag{9}$$