Erratum

Coulomb quantum kinetics in pulse-excited semiconductors

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Z. Phys. B91, 199 (1993)

In the treatment of the quantum kinetics of an interacting electron-hole system excited by a short laser pulse we used as a starting point the generalized Kadanoff-Baym equation (10) derived by Langreth in order to justify that we included renormalization terms together with scattering terms. In equation (10) the time integrals run from $-\infty$ to $+\infty$, which makes this formulation very suited if one wants to introduce a Fourier transformation with respect to the relative time. For our purpose, however, one should start with the original quantum kinetic equation (7) which follows directly with the contour time ordering for non-equilibrium Green functions for the particle propagator $G^<(t_1, t_2)$

$$G_0^{-1} G^< = \Sigma' G^< + \Sigma^< G^a.$$

The intermediate time integral in the two terms run from the initial time $-\infty$ to t_1 and t_2 , respectively. The retarded self-energy and the advanced Green function can be expressed by particle-like functions:

$$G^a(t_1, t_2) = -\Theta(t_2 - t_1)(G^>(t_1, t_2) - G^<(t_1, t_2))$$

and

$$\begin{aligned} \Sigma'(t_1, t_2) = & \Sigma^s(t_1) \delta(t_1 - t_2) \\ & + \Theta(t_1 - t_2)(\Sigma^>(t_1, t_2) - \Sigma^<(t_1, t_2)). \end{aligned}$$

Here $\Sigma^s(t)$ is the singular part of the self-energy which has to be treated separately as stressed e.g. by Danielewicz [1]. In our problem the singular self-energy matrix with the band indices $(\rho, \nu) = (c, v)$ is

$$\Sigma_{\rho\nu}^s(t) = -d_{\rho\nu} E(t)(1 - \delta_{\rho\nu}) + \Sigma_{\rho\nu}^{HF}(t),$$

where the first term describes the interband transitions due to the coherent laser field and the second one is the

intraband Hartree-Fock Coulomb self-energy. In our paper we treated as an approximation the retarded and advanced screened Coulomb potential as an instantaneous static potential

$$V_{sq}(t_1, t_2) = V_{sq}(t_1) \delta(t_1 - t_2).$$

In this case also the correlation energy becomes singular so that

$$\Sigma_{\rho\nu}^s(t) = -d_{\rho\nu} E(t)(1 - \delta_{\rho\nu}) + \Sigma_{\rho\nu}^{\text{RPA}}(t),$$

where $\Sigma_{\rho\rho}^{\text{RPA}}(t)$ is the static RPA intraband self-energy used in the treatment. The resulting quantum kinetic equation can be written symbolically as

$$\begin{aligned} [G_0^{-1}, G^<]_{t=t'} - [\Sigma^s(t), G^<(t, t)] \\ = \int_{-\infty}^t dt_2 (\{\Sigma^>, G^<\} - \{\Sigma^<, G^<\})_{t=t'}, \end{aligned}$$

where $[,]$ and $\{, \}$ are commutators and anticommutators. The explicit quantum kinetic equations (20), (27) and (28) follow directly from this form. Particularly, all numerical results of our paper remain unchanged by this corrected derivation of quantum kinetic equations. Note that this procedure with the nonretarded screened Coulomb potential approximation yields the collision term in the Born approximation which one would have obtained in second order starting with an instantaneous interaction potential.

References

1. Danielewicz, P.: Ann. Phys. **152**, 239 (1984)