A complete multifluid model for bipolar semiconductors

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If electrons (e) and holes (h) in metals or semiconductors are heated to the temperatures T_e and T_h greater than the lattice temperature , the electron-phonon interaction causes energy relaxation [3]. In the non-uniform case a momentum relaxation occurs as well. In view of such an application, a new model, based on an asymptotic procedure for solving the kinetic equations of carriers, phononsand photons is proposed, which gives naturally the displaced Maxwellian at the leading order.

Several generation-recombination (GR) events occur in bipolar semiconductors. In the presence of photons the most important ones are the radiative GR events, direct, indirect and exciton-catalyzed. Phonons and photons are treated here as a participating species, with their own equation. All the phonon-photon interactions are accounted for. Moreover carrier-photon (Compton) interactions are introduced, which make complete the model.

After that, balance equations for the electron number, hole number, energy densities, and momentum densities are constructed, which constitute now a system of macroscopic equations for the chemical potentials (carriers), the temperatures (carriers, and bosons), and the drift velocities (carriers, and bosons). In the drift-diffusion approximation the constitutive laws are derived and the Onsager relations recovered, even in the presence of an external magnetic field.

The treatment resorts here strictly to kinetic theory, so that the model is closed. This means that we do not need to adjust the relaxation times by means of comparisons with Monte Carlo calculations. The fulfilment of Onsager symmetry is not trivial, since it cannot given for granted in many macroscopic models.

We stress the following extensions, with respect to a previous paper [1]:

i)photons are described as a participating species, with their own kinetic equation; ii) Phonon-photon and carrier-photon (Compton) interactions are introduced; iii) exciton-catalyzed generation-recombination is accounted for; iv) a detailed discussion on Onsager symmetry is given.

[l] A. Rossani, Cont. Mech and Therm **28**, 1672 (2016).

[2] A. Rossani, Phys. A **390**, 3329 (2011).

[3] P.B. Allen, Phys. Rev. Lett. **59**, 1460 (1987).