A new finite differences scheme for Boltzmann equation on semiconductor devices

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We solve the Boltzmann equation

$$\frac{\partial f}{\partial t} + \mathbf{u} \cdot \nabla_x f + \frac{e}{m} \nabla \phi \cdot \nabla_{\mathbf{k}} f = Q(f) \tag{1}$$

in a $n^+ - n - n^+$ silicon device, where f is the probability density function, $\mathbf{k}$ is the wave vector related with the electron energy ε through the Kane relation and $\mathbf{u}$ is the electron velocity. The electric field $\mathbf{E}$ is obtained, selfconsistently, by the Poisson equation:

$$\nabla \cdot \nabla \phi = \frac{e}{\epsilon}(n(x) - N_D(x)) \tag{2}$$

$$\mathbf{E} = -\nabla \phi \tag{3}$$

where ϵ is the permittivity of the crystal, $n(x)$ is the electron density and $N_D(x)$ is the donor density. The collision operator is

$$Q(f) = \int_{\Re^3} [S(\mathbf{k}', \mathbf{k}) f' - S(\mathbf{k}, \mathbf{k}') f] d\mathbf{k}' \tag{4}$$

where $S(\mathbf{k}, \mathbf{k}')$ is the scattering operator which takes into account the scattering between electrons and phonons.
Because of the spherical symmetry of the distribution function f, we can use the energy ε and one angle μ in the velocity space as independent variables.
We discretize system (1) - (4) on a uniform grid but it could be easily extended to a non uniform one.
The direct solution of (1) allows us to obtain authomatically the physical quantities of interest, like velocity and density of the electric charges in the device.

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